Energy, Mines and Resources Canada
Énergie, Mines et Ressources Canada

WIND ENERGY CONVERSION POTENTIAL OF REMOTE COMMUNITIES ON THE LABRADOR COAST

Canada

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WIND ENERGY CONVERSION POTENTIAL

OF REMOTE COMMUNITIES ON THE LABRADOR COAST

Prepared for:

Remote Community Demonstration Program
of Energy, Mines and Resources Canada

Prepared by:

ShawMont Newfoundland Limited

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EXECUTIVE SUMMARY

Approximately 79 communities in Newfoundland and Labrador are served by grid - isolated diesel generation systems. This study, commissioned by Energy, Mines and Resources Canada in November 1984, was to carry out a preliminary assessment of potential wind energy conversion system* sites and to identify suitable wind turbine installation for each of the potential sites in 14 communities on the Labrador coast which meet the criteria of the Remote Community Demonstration Program. These communities are Nain, Davis Inlet, Postville, Makkovik, Rigolet, Paradise River, Cartwright, Black Tickle, Charlottetown, William's Harbour, Port Hope Simpson, Saint Lewis, Mary's Harbour and L'Anse au Loup.

The study generally comprised three components:

.1 Collection, organization and evaluation of secondary source data.

.2 Matrix evaluation, site descriptions and selection of best sites.

.3 Technical review and selection of WECS machines.

The Site Assessment Methodology developed for the South Coast Wind Study**as well as data on wind turbines and wind intergration experience accumulated in carrying out the South Coast Study has been utilized extensively in the preparation of this supplementary report.

The site assessment methodology basically consisted of evaluating each of the 14 communities using a weighted matrix technique. The weighting categories being:

Windfield
Topography
Safety
Icing
Soils and Geology
Equipment and Skill Availability
Access
Social Impacts
Land Acquisition
Demonstration Visibility
Electro Magnetic Interference
Connecting Distance
Minimum System Demand

The assessment and evaluation of the 14 communities, carried out as a desk study, identified six communities as having a site with potential to support a WECS installation, with the following weightings:

* In future references, abbreviated to: WECS

** This study, entitled "Wind Energy Conversion System, South Coast Region of Newfoundland, Prefeasibility Study" was prepared for Newfoundland and Labrador Hydro with a contribution from the Remote Community Demonstration Program of Energy, Mines and Resources Canada (RCDP report number: RCDP/PDCE-45), Dec. 1984.

EXECUTIVE SUMMARY (Cont'd)

Cartwright	115
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Makkovik	105
Saint Lewis	105
Nain	85
Paradise River	80

The selection of WECS machines for each site was based upon the technical feasibility of the respective diesel generator systems to support a contribution from a wind turbine generator considering two modes of operaton: ie. with and without special load control features.

The wind turbines were selected from the list of machines identified through the South Coast Wind Study from a total of 46 parameters in the following categories:

General
Wind Speed
Guarantee
Physical Constraints
Experience
Costs

The WECS selected for each site are as follows:

Uncontrolled System

Nain

Maximum rating for WECS - 11 kW.

WECS Selected	Max. Power	Weighting
Enertech	5.3 kW	9280 pts

Paradise River

Maximum rating for WECS - 5 kW.

WECS Selected	Max. Power	Weighting
Enertech	5.3 kW	9280 pts

EXECUTIVE SUMMARY (Cont'd)

Uncontrolled System (Cont'd)

Cartwright

Maximum rating for WECS - 68 kW.

WECS Selected	Max. Power	Weighting
Enertech	44 kW	12375 pts
Moerup	65 kW	11091 pts
Daf-Indal	52 kW	11028 pts
Howden	60 kW	10925 pts

Saint Lewis

Maximum rating for WECS - 20 kW.

WECS Selected	Max. Power	Weighting
Northwind	16 kW	11016 pts
Windtech	20 kW	8137 pts

L'Anse An Loup

Maximum rating for WECS - 140 kW.

WECS Selected	Max. Power	Weighting
Windmaster	125 kW	10486 pts
Polymarin	100 kW	8834 pts
Adecon	125 kW	8175 pts

Controlled System

Nain

Maximum rating for WECS - 224 kW.

WECS Selected	Max. Power	Weighting
Howden	200 kW	11147 pts
Windmaster	215 kW	10437 pts

EXECUTIVE SUMMARY (Cont'd)

Controlled System (Cont'd)

Makkovik

Maximum rating for WECS - 148 kW.

WECS Selected	Max. Power	Weighting
Moreup	65 kW	11091 pts
Howden	100 kW	10925 pts
Windmaster	125 kW	10486 pts
Vesta	78 kW	10437 pts
Wintech	80 kW	9003 pts
Polymarin	100 kW	8839 pts
Adecon	125 kW	8175 pts

Paradise River

Maximum rating for WECS - 41 kW.

WECS Selected	Max. Power	Weighting
Enertech	27 kW	11413 pts
Man	33 kW	10490 pts
Wintech	20 kW	8137 pts
Extrawatt	30 kW	6095 pts

Cartwright

Maximum rating for WECS - 272 kW.

WECS Selected	Max. Power	Weighting
Howden	200 kW	11147 pts
Windmaster	215 kW	10437 pts

Saint Lewis

Maximum rating for WECS - 143 kW.

WECS Selected	Max. Power	Weighting
Moerup	65 kW	11091 pts
Howden	100 kW	10925 pts
Windmaster	125 kW	10486 pts
Vesta	78 kW	10437 pts
Wintech	80 kW	9003 pts
Polymarin	100 kW	8839 pts
Adecon	125 kW	8175 pts

EXECUTIVE SUMMARY (Cont'd)

Controlled System (Cont'd)

L'Anse Au Loup

Maximum rating for WECS - 968 kW.

WECS Selected	Max. Power	Weighting
Howden	333 kW	10925 pts
Carter	280 kW	10887 pts
Daf-Indal	522 kW	10198 pts
FDO Stork	300 kW	8489 pts

POSSIBILITÉ DE CONVERSION DE L'ÉNERGIE ÉOLIENNE DANS LES COLLECTIVITÉS ÉLOIGNÉES DE LA CÔTE DU LABRADOR

Résumé

Il y a à Terre-Neuve et au Labrador quelque 79 collectivités desservies par des centrales électriques alimentées au diesel, hors réseau. La présente étude, réalisée à la demande d'Énergie, Mines et Ressources Canada en novembre 1984, avait pour but d'effectuer une évaluation préliminaire des sites propices à l'aménagement de systèmes de conversion de l'énergie éolienne (SCEE) et de déterminer le type d'aérogénérateur convenant le mieux à chacun de ces sites. L'étude portait sur 14 collectivités de la côte du Labrador répondant aux critères du Programme de démonstration dans les collectivités éloignées, à savoir: Nain, Davis Inlet, Postville, Makkovik, Rigolet, Paradise River, Cartwright, Black Tickle, Charlottetown, William's Harbour, Port Hope Simpson, St. Lewis, Mary's Harbour et L'Anse-au-Loup.

L'étude comportait essentiellement trois volets:

1. Le rassemblement, le classement et l'analyse des données de sources secondaires.

2. L'évaluation matricielle, la description des sites possibles et la sélection des meilleurs sites.

3. L'analyse des caractéristiques techniques et la sélection des SCEE.

La méthode d'évaluation des sites élaborée dans le cadre de l'étude préalable de faisabilité intitulée "Système de conversion de l'énergie éolienne - Côte sud de Terre-Neuve" ainsi que les données sur les aérogénérateurs et l'expérience en matière d'intégration des vents acquise au cours de l'étude susmentionnée ont, dans une grande mesure, servi à l'établissement du présent rapport supplémentaire.

La méthode d'évaluation consistait fondamentalement à évaluer chacune des 14 collectivités au moyen d'une technique de matrice pondérée, dont les catégories de pondération étaient: la page de vitesses du vent; la topographie; la sécurité; le givrage; les sols et la géologie; la disponibilité du matériel et des compétences; l'accès; les répercussions sociales; l'acquisition des terres; la visibilité de la démonstration; l'interférence électromagnétique; la distance de connexion; la demande minimale du réseau.

Cette évaluation des 14 collectivités, réalisée sous forme d'étude conceptuelle, a permis d'établir que six collectivités possèdent un site propice à l'installation d'un SCEE. Voici le facteur de pondération accordé à chacune d'elles:

- Cartwright 115
- L'Anse-au-Loup 115
- Makkovik 105
- St. Lewis 105
- Nain 85
- Paradise River 80

On a choisi les SCEE pour chaque site en fonction de la capacité technique des génératrices alimentées au diesel afin de supporter l'apport d'un aérogénérateur, compte tenu de deux modes de fonctionnement, c'est-à-dire avec ou sans régulateur de charge.

Les aérogénérateurs ont été choisis à partir de la liste établie dans le cadre de l'étude intitulée "Systèmes de conversion de l'énergie éolienne-Côte sud de Terre-Neuve -", d'après 46 paramètres regroupés dans les catégories suivantes:

- caractéristiques générales
- vitesse du vent
- garantie
- restrictions d'ordre matériel
- expérience
- coûts

Voici les SCEE choisis pour chaque site:

SANS RÉGULATEUR

Collectivité	Puissance limite acceptable pour les SCEE	SCEE choisis		Pondération
Nain	11 kW	Enertech	5,3 kW	9 280 points
		Windmaster	2,5 kW	
Paradise River	5 kW	Enertech	5,3 kW	9 280 points
Cartwright	68 kW	Enertech	44 kW	12 375 points
		Moerup	65 kW	11 091 points
		Daf-Indal	52 kW	11 028 points
		Howden	60 kW	10 925 points
St. Lewis	20 kW	Northwind	16 kW	11 016 points
		Windtech	20 kW	8 137 points
L'Anse-au-Loup	140 kW	Windmaster	125 kW	10 486 points
		Polymarin	100 kW	8 834 points
		Adecon	125 kW	8 175 points

AVEC RÉGULATEUR

Collectivité	Puissance limite acceptable pour les SCEE	SCEE choisis		Pondération
Nain	224 kW	Howden	200 kW	11 147 points
		Windmaster	215 kW	10 437 points
Makkovik	148 kW	Moerup	65 kW	11 091 points
		Howden	100 kW	10 925 points
		Windmaster	125 kW	10 486 points
		Vesta	78 kW	10 437 points
		Windtech	80 kW	9 003 points
		Polymarin	100 kW	8 839 points
		Adecon	125 kW	8 175 points
Paradise River	41 kW	Enertech	27 kW	11 413 points
		Man	33 kW	10 490 points
		Wintech	20 kW	8 137 points
		Extrawait	30 kW	6 095 points
Cartwright	272 kW	Howden	200 kW	11 147 points
		Windmaster	215 kW	10 437 points
St. Lewis	143 kW	Moerup	65 kW	11 091 points
		Howden	100 kW	10 925 points
		Windmaster	125 kW	10 486 points
		Vesta	78 kW	10 437 points
		Wintech	80 kW	9 003 points
		Polymarin	100 kW	8 839 points
		Adecon	125 kW	8 175 points
L'Anse-au-Loup	968 kW	Howden	333 kW	10 925 points
		Carter	280 kW	10 887 points
		Daf-Indal	522 kW	10 198 points
		FDO Stork	300 kW	8 489 points

La présente étude a été réalisée par le ShawMont Newfoundland Limited dans le cadre du Programme de démonstration dans les collectivités éloignées d'Énergie, Mines et Ressources Canada.

PART ONE

INTRODUCTION

1.0 INTRODUCTION

There are 14 remote communities along the Labrador coast which meet the criteria of the Remote Communities Demonstration Program. These communities are: Nain, Davis Inlet, Pastville, Makkovik, Rigolet, Paradise River, Cartwright, Black Tickle, Charlottetown, William's Harbour, Port Hope Simpson, St. Lewis, Mary's Harbour and L'Anse au Loup. The program is designed to sponsor feasibility studies and subsequently a limited number of demonstration projects to promote the awareness and adoption of alternative energy sources and technologies and enchance energy conservation schemes expressly for remote communities, in an effort to reduce the dependence of these communities on diesel oil.

This study, commissioned by Energy, Mines and Resources Canada under the RCDP, involved the evaluation of the Labrador coast communities for WECS potential and the identification of wind turbines best suited to the selected sites. The site evaluation, comprising a desk study, has been based on the Site Assessment Methodology for Remote Communities developed for the South Coast Wind Study. The selection of suitable WECS for each of the sites was based on the experience gained and manufacturer's wind turbine data accummulated in carrying out the South Coast Wind Study.

The study has two main components which are:

.1 Locational (Site) analysis.
.2 Technical (Wind Turbine) analysis.

The report is divided into five main sections. Part Two outlines the collection, organization and evaluation of the secondary source data and development of the site evaluation matrix. Part Three details the site descriptions, evaluation and final selection of the best sites. Part Four comprises a technical review and selection of wind turbines for each of the selected sites. Part Five summarizes the conclusion and recommendations reached during the study.

PART TWO

SECONDARY SOURCE DATA

2.1 GENERAL

To carry out a detailed evaluation of each community/site it is necessary to collect as much relevant information as possible on each community in the region from the following sources:

	Agency	Information	Location and Contact (Appendix D)
1.	Atmospheric Environment Service Canada	Wind & Ice Data	Reference 1 & 2

The amount of data available from AES locally is extremely limited. AES in Downsview has access to all the statistics available and can carry out computer analyses on specific parameters. Their turnaround time for this service is approximately 2 weeks and the fee charged is very reasonable.

2.	Newfoundland and Labrador Dept. of Forest Resources & Lands	Topographic Mapping & Aerial Photographs	Reference 3

The mapping division of this department will provide 1:50,000 scale maps of any area in the province on request. Larger scale mapping is available only for the Avalon Peninsula and the coverage for the orthophoto mapping is extremely limited. The turnaround time of aerial photographs is approximately 3-4 weeks.

3.	Newfoundland and Labrador Dept. of Mines & Energy	Surficial Geology	Reference 4

Data available on request.

4.	Energy, Mines Resources Canada	- Overview Study - Remote Community Demonstration Program Criteria	Reference 5

Data available on request for Communities in the region of interest. The Overview Study has carried out the basic social and cultural research.

5.	Newfoundland and Labrador Hydro	Diesel Generator System Characteristics.	Reference 8

2.1 GENERAL (Cont'd)

6.	Dept. of Communications	Communication Systems Infromation	Reference 6
7.	Memorial University	Background Literature	Reference 7
8.	Local Community District Authorities	Local Input	Reference 9

2.2 COLLECTION OF SECONDARY SOURCE DATA

The first step in the collection of secondary source data was to obtain all relevant wind data from AES. This was done and based on the limited data available for the Labrador coastal region it was determined that the average annual wind speed for all of the communities to be studied was adequate.

Once the adequacy of the windfield in the study locations had been established the task of collecting as much of the remaining secondary source data as possible was started. Following is a brief summary of the data sources and information collected.

1) Newfoundland and Labrador Department of Forest Resources and Lands provided the following information:

   a) 1:50,000 scale topographic maps of all areas being studied;
   b) aerial photographs of every community being studies except Nain, and
   c) town maps of all communities except William's Harbour and Davis Inlet.

2) Energy, Mines and Resources Canada provided a copy of the Remote Community Demonstation Program Criteria.

3) Department of Communications provide a map of Newfoundland and Labrador outlining the position of communication installations on the coast of Newfoundland.

4) The Newfoundland and Labrador Intergovernment Affairs Secretariat provided the names and addresses of contacts in the Labrador communities who would act as distribution points of the questionnaire.

2.2 COLLECTION OF SECONDARY SOURCE DATA (Cont'd)

5) The contacts referred to above were telephoned. During the conversation the general results of the survey were determined and other relevant community information was gathered. A copy of the questionnaire used for this study appears in Appendix A.

6) Newfoundland and Labrador Hydro supplied diesel plant operation information including the number and size of diesel generators in each community and the community load characteristics.

2.3 EVALUATION MATRIX

The final phase of the desk study involves determining which of the communities studies has the highest potential for supporting a WECS. To do this an evaluation matrix was designed. The following text describes the categories included in the matrix evaluation and the weights applied to each item. The scoring system will allow for one or more WECS site per community.

2.3.1 Windfield

As previously stated, the windfield for each candidate site will be given a "Yes" or "No" rating. A "Yes" designation for any site will indicate that the regional wind regime is believed to be sufficient to power a WEC system. A "No" on the windfield for any site indicates that the wind regime is not sufficient to drive a WECS and the site will be disqualified. An average annual wind speed of 20 km/h will be the minimum acceptable for a site to qualify for a WECS installation.

2.3.2 Topography

Topography is classified as one of the following groups:

-- Flat Terrain
-- Non Flat Terrain

Each site at the various communities will be placed in one of the above categories and their location assessed based on the information given in Section 3.1.1. If the site is in a location which is inaccessable or is too distant (greater than 2 km) from the community the topography is scored with a "No" and the site disqualified. If the site is in a favourable location then it is given "Yes" and subjected to the following scoring scheme.

2.3.2 Topography (Cont'd)

1. The site is exposed to the wind from all directions and there is no terrain features within 10 km which could create unacceptable wind patterns such as turbulence and wind shear 30 points

2. The site is exposed to wind from all directions but there are higher points of land within 10 km of the site 20 points

3. The site is exposed to the prevailing wind but blocked by higher features in other directions 10 points

4. The site is located in a potential area of high turbulence 0 points

2.3.3 Safety

The safety factor in the installation of a WECS machine is one that must be considered. The principal hazards associated with a WECS system are thrown ice or a thrown blade striking a dwelling or person.

Based on the literature search, it is recommended that any WECS site be at least 230 m from the nearest dwelling. It is further recommended that if these criteria cannot be met then the site should be disqualified. Safety will be scored with a YES/NO.

2.3.4 Icing

In areas that experience freezing rain and drizzle, ice accumulations on blades, towers and transmission lines can reduce efficiency and availability and, in severe cases, destroy the wind machine. There are two types of icing: rime ice and glaze ice. Rime ice forms as a result of freezing fog or frost. It is generally less dense than glaze ice and therefore less hazardous. Glaze ice forms as a result of freezing rain which freezes on contact and can accumulate to several inches. Heavy icing caused by freezing rain could cause structural failure in a WECS.

To determine icing potential for a given site, there are three possible sources of information. These are:

-- Data collected by the Atmospheric Environment Service.
-- Information from local residents on historic icing conditions in the community.
-- Utility Companies

2.3.4 Icing (Cont'd)

Icing data available for AES details icing events on an hourly basis but does not list the degree of accumulation. However, most wind machines have systems by which they can shut down should ice loading become a problem and ice is then only a major problem in two senses, - frequency of occurrence and total weight of ice.

.1 Frequency of Occurrence

Ice data from AES stations and Marine statistics can be obtained from AES Downsview and is compiled by event occurrence only. Neither the ice build up is calculated nor is the duration of the event indicated. However, because most WECS are protected such that the machine will shut down when vibration occurs, the number of events becomes a relevant statisitic. If a worst case scenario of machine shut down on each hourly occurrence of the freezing precipitation is calculated then it is possible to approximate the number of days per year lost due to icing. Also to be considered is the fact that ice may persist on a surface after a storm due to the continuation of freezing temperature conditions.

.2 Total Weight of Ice

This is directly related to the worst possible ice storm and the survival characteristics of the wind machine and tower. This worst case scenario will be subjectively evaluated in discussion with local residents as to their recollection of major storms.

To evaluate the candidate sites a point scoring system will be used as follows:

(a) Less than 200 events of freezing precipitation per year - 10 points

(b) 200 - 500 events of freezing precipitation per year - 5 points

(c) over 500 events of freezing precipitation per year - 0 points

2.3.5 Soils and Geology

To evaluate the difficulty of installation and the materials and equipment required to erect a WECS, it is necessary to know the geology of the sites. The geology may be obtained by examining aerial photographs and geological maps. There are three basic types of surface material which are of interest when erecting a WECS in Newfoundland. There are: bedrock, till and bog.

2.3.5 Soils and Geology (Cont'd)

Bedrock is the most favourable medium as it requires limited equipment and no major foundation work to erect the tower. To erect a tower on till would require digging equipment and foundation. The third type of surface material which may be encountered is bog. This is extremely difficult to work on unless it is very shallow (less than 1 metre) and should be avoided.

In evaluating the soils and geology portion of the matrix, the following scoring will be used:

(a)	Exposed or thinly covered bedrock	- 10 points
(b)	Till	- 5 points
(c)	Bog	- 0 points

2.3.6 Equipment and Skill Availability

The availability of equipment and skill in remote communities is not considered to be of prime importance in the site selection process. The erection of a WECS is a specialized job and may require personnel familiar with this type of installation. In most cases, heavy equipment necessary to the installation, if not available at the site, could be brought in either by road or boat.

The scoring scheme for equipment and skill availability in the matrix are as follows:

(a)	All necessary equipment and skill available at site	- 10 points
(b)	Some equipment and skill available at site	- 5 points
(c)	No equipment available	- 0 points

2.3.7 Access

Accessibility to the community and the specific site is very important in site selection as it can impact dramatically on the economic feasibility of the project.

Accessibility to the community is necessary to deliver the WECS and related equipment. It is necessary to know what type of transportation links (sea, road, air) service each community. This information can be obtained by consulting a map or direct inquiry with the community by mail or telephone. This information will aid in determining the economics of installation of the WECS for a given site.

2.3.7 Access (Cont'd)

Information respecting specific site access is required to determine such details as the length of access road required and ownership of access land.

Matrix scoring for accessibility will be as follows:

(a) Community accessible by road, and boat with site accessible by road - 25 points

(b) Community accessible by boat and road with site requiring construction or upgrading of access road - 15 points

(c) Community accessible by boat with site accessible by road - 20 points

(d) Community accessible by boat with site requiring construction or upgrading of access road - 10 points

(e) Community assessible by boat with site requiring extensive construction of access road - 5 points

(f) Community accessible by boat only and construction of access road to site not feasible requiring helicopter for equipment transport. - 0 points

2.3.8 Social Impacts

The social impacts associated with the installation of a WECS system are expected to be minimal yet they bear important consideration. The most immediate positive impact will be the short term employment for some local residents during construction of the access road, if required, and possibly the erection of the machine(s).

The primary method of social impacts evaluation will be the a questionnaire polling residents for their opinions. A sample copy of the questionnaire appears in Appendix A.

Scoring for this category will be as follows:

(a) Positive impacts such as job creation; very positive attitude shown by the community towards the system. - 10 points

(b) Social impact minimal or none, yet interest in community is high. - 5 points

(c) Social impact minimal with very little interest shown on the part of the community. - 0 points

2.3.9 Acquisition

When a potential WECS site is considered, the ownership of the land and whether it is available for purchase or lease must be taken into account. If the potential site is privately owned, the cost of acquiring the land may be prohibitive. If the land is publicly owned, then permission must be obtained to purchase or lease the land from the government in charge. In Newfoundland, this is not usually a problem unless the land is within Provincial or National Park boundaries.

Scoring for acquisition within the matrix is as follows:

(a) The site is on crown land which is readily available for lease or purchase at a minimum cost. - 10 points

(b) The site is on restricted government property where acquisition will be difficult or on privately owned land which involves purchase negotiation. - 5 points

(c) The site is privately owned and cost of acquisition is not economically feasible. - 0 points

2.3.10 Demonstration Visibility

For the purposes of this project, site selection with regards to demonstration visibility is being considered in the evaluation process.

Scoring for the demonstration visibility will be as follows:

(a) WECS located in population centre of more than 2,000 people. - 5 points

(b) WECS located in population centre of 1,000 to 2,000 people - 3 points

(c) WECS located in population centre of less than 1,000 people. - 0 points

2.3.11 Electro Magnetic Interference (EMI)

As WECS machines are a potential source of electro magnetic interference, it is very important that the site be selected so as not to interefere with television and microwave reception. This situation can be avoided by selecting a site out of the direct line of transmission. The best method for determining transmission direction is to have questionnaire respondents note the direction of TV antennas on houses in their areas and the strength of their TV signal. A map indicating the location of TV transmitters in Newfoundland and Labrador is located in Appendix B.

2.3.11 Electro Magentic Interference (EMI) (Cont'd)

Scoring for EMI will be as follows:

1. Site completely removed from line of transmission. 15 points

2. Site close to line of transmission but potential intereference unlikely. 10 points

3. Site in direct line of transmission 0 points

2.3.12 Connection Distance

The location of the WECS site will dictate the length of transmission line that must be run to connect the WECS to the existing distribution lines. A long connection line will negatively effect the economics of the site especially if the terrain is very rugged, as it is in most areas. Evaluation of each site for connection distance is as follows:

1.	Less than 0.2 km	20 points
2.	0.2 to 0.4 km	15 points
3.	0.4 to 0.6 km	10 points
4.	0.6 to 0.8 km	5 points
5.	0.8 to 1 km	0 points

Connection distances greater than one km will have to be separately and very critically reviewed with respect to the specific system being considered. A large WECS system may be able to accommodate the cost of a longer transmission line, whereas this would probably be uneconomical for a small system.

2.3.13 Minimum System Demand

The largest WECS that can be safely operated with existing diesel generator systems is a function of the minimum system load and the size of the on-line diesel generator(s) normally operated to service this load. (If the minimum load is not on record or known, the plant operating personnel will be required to produce a series of daily load profiles). Generally the higher the minimum load, the greater the potential for WECS. The following weighting scheme will apply for minimum load evaluation in each community:

1.	Minimum load above 60 kW	15 points
2.	Minimum load between 30 - 60 kW	10 points
3.	Minimum load between 20 - 30 kW	5 points
4.	Minimum load less than 20 kW	0 points

2.3.13 Minimum System Demand (Cont'd)

If the minimum system load is so low, say less than 10 kW, and it is virtually impossible to adequately penetrate it with any of the commercially available, proven WECS, then the decision will have to be made to abandon this community, regardless of how well it scores on the other categories.

PART THREE

SITE INVESTIGATION AND SELECTION

3.1 GENERAL METHODOLOGY

The methodology of selecting potential WECS sites is designed around the evaluation matrix which permits the assignment of numerical values to the relevant characteristics of potential WECS sites as described in section 2.3 of this report. Prior to completing the evaluation matrix, however, the windfield in each community must be roughly quantified in order to assign a 'Yes' or 'No' rating to this characteristic.

To do this the wind information gathered via the questionnaires is studied in conjunction with wind data from weather station nearest each community. The position on the Labrador Coast of each community being studied is shown on Figure 3.1. Figure 3.2 shows the location of all weather stations in the region and summarizes the wind data for each station in the form of a wind rose. The evaluation matrix was then completed by assembling the secondary source date and performing the following tasks.

3.1.1 Terrain Evaluation

The topography in each community area was viewed with the purpose of estimating the wind flow patterns around the terrain, pinpointing areas of possible turbulence and selecting potential locations for wind measurement preferably away from this turbulence. Topography in any given area can be classified into either flat or non flat terrain (Wegley, 1980), as follows:

.1 Flat Terrain

No terrain is really flat as there are always small irregularities or large gently sloping features, however, with respect to small scale terrain irregularities, terrain may be considered flat if:

- -- elevation differences between the wind turbine site and the surrounding terrain are not greater than 50 m within 10 km of the site
- -- no hill has an aspect ratio (height divided by diameter) greater than 1/50 within 5 km upstream and 1 km downstream of the site (Frost, 1981)

These parameters may be determined by examining a 1:50,000 topographic map and aerial photographs. In Newfoundland, the occurence of flat terrain is usually restricted to areas such as barrens, large bogs and, occasionally, coastal flats.

3.1.1 Terrain Evaluation (Cont'd)

.2 Non Flat Terrain

Non Flat terrain is divided into two groups: small scale and large scale terrain.

For the purposes of WECS siting, the difference between small and large scale terrain is determined by how much effect a particular geographic feature or area has on the planetary boundary layer (PBL). The PBL is, roughly, the first kilometer of atmosphere where the direct effect of turbulent transfer of heat and momentum is observable. Small scale features are those which do not significantly alter the wind flow in the PBL.

A large scale feature is one that extends through a significant portion of the PBL or even above the height of the PBL and significantly modifies the structure of the entire boundary layer resulting in wind turbulence which must be avoided when siting a WECS.

As it is not possible to determine the height of the PBL without expensive monitoring and testing procedures small scale terrain will be defined as any feature which is less han 100 m in height while large scale is any feature greater than 100 m in height.

These heights are guidelines only and it should be noted that unacceptable turbulence may be associated with small scale features as well as with large.

As with flat terrain, analysis of non flat terrain is carried out using topographic maps and aerial photographs.

Some geographic features accent the wind rather than impede it and were looked for when carrying out the preliminary site evaluations. Some of these features are:

-- relatively flat smooth areas
-- small ridges normal to the prevailing wind
-- small cliffs facing upwind - location of the WECS above a concave section is best
-- small hills with slopes in the vicinity of 30% (can be determined from cross sections)
-- ridge and mountain upper slopes - these have stronger winds and less diurnal variation than a valley.

3.1.1 Terrain Evaluation (Cont'd)

.2 Non Flat Terrain (Cont'd)

Some areas which should be avoided when siting a WECS are as follows:

-- in the lee or at the base of hills

-- small valleys

-- small basins

-- small gaps between larger features
-- flat topped large ridges and mountains - these may produce wind shear and flow separation.

3.1.2 Aerial Photo Interpretation Analysis of Sites

Using the background data from 3.1.1, the aerial photographs and topographic maps, for each community were evaluated as to potential WECS sites.

"Does the topography obviously preclude some communities?"

This aspect was intended to be a cursory look and was limited to an assessment of whether or not the local terrain is totally inaccessible.

"Can potential WECS sites be identified within close proximity (0.3 km to 2 km) of the community?"

Increasing distance from the existing distribution system directly affects the economic viability of the installation. Having initially identified potential sites, the following method was employed:

.1 Cross Sections

Construct cross sections of the likely sites in the direction of the prevailing winds. This method enables the analyst to get a good appreciation of the vertical characteristics of the area around the communities and allows calculation of the slope at the site.

3.1.3 Assessment of Questionnaire Results

As terrain evaluation and aerial photo interpretation progressed the results of completed questionnaires were collected by phone. The data contained in the questionnaires was then summarized for each community as shown in Table 3.1. Information from the questionnaires was then utilized in completing the evaluation matrix.

3.2 SITE DESCRIPTIONS

Each site was investigated as outlined above and all parameters specified in the Assessment Methodology were appropriately quantified. The wind resource in each community was subjectively assessed using the regional wind information from AES, and the estimates of daily wind speeds and direction provided by the local inhabitants in telephone conversations and on the questionnaires. The description of each community and the potential sites in each community are presented below. The descriptions were derived from assessment of maps and air photos, and refined by information collected from the questionnaires. The Community characteristics are summarized in Table 3.3

.1 Nain

Established in 1771 Nain is the northern most community in Labrador. Situated on Unity Bay at geographic co-ordinates Latitude 56° 32' N, Longitude 61° 41' W. Nain has a population of 938 people who earn their living from fishing, hunting and trapping. Offshore oil exploration is expected to provide a large economic boost to the community over the next ten years.

Access to Nain is provided by Labrador Airways and CN Marine coastal boats. Three 300 kW and one 450 kW generators provide power to the community and its industries. The power plant is operated by Newfoundland and Labrador Hydro (NLH) and is located at the southern end of town. Load characteristics for the community are a minimum load of 131 kW, a peak load of 464 kW and an annual energy consumption of 2,214 MWh.

There is a good road network in the Town proper. However, beyond the Town there are no paths for vehicular traffic other than snowmobiles.

The terrain surrounding Nain is rolling hills with heights up to 250 m. A promising site appears to be a hilltop at elevation 200 m a distance of 550 m northwest of the community (Figure 3.3).

3.2 SITE DESCRIPTIONS (Cont'd)

.2 Davis Inlet

Located at geographic co-ordinates 55° 48' N, 59° 55' W, David Inlet is a small community of 241 inhabitants. The Community has a minimum load of 30 kW, a peak load of 129 kW and an annual energy consumption of 604 MWh. Installed generation of the diesel plant is two 136 kW units and one 60 kW unit.

The Town is located in the Labrador Sea to the east of Ukasiksalk Island on Iluikoyak Island. To the east, west and south of the community are hills a minimum of 200 m high which may interfer with the wind regime.

Access to Davis Inlet is available by Labrador Airways and CN coastal boat. Within the community there is a well established road network but outside of town travel would be restricted to foot or snowmobile. Dock facilities appear sufficient for offloading and loading construction equipment.

The geology of the area comprises exposed rock on the high points of the hills with some vegetation cover on the hillsides and between hills. The surrounding terrain is large scale with hills as high as 390 m within 8 km.

Prevailing winds are westerly as is the case all along the Labrador coast. The windfield velocity is expected to be similar to that recorded at Hopedale.

The best site for a WECS appears to be on a hill 500 m west of Davis Inlet at elevation 100 m (Figure 3.4). This site, however, is only completely exposed to northerly winds and is partially sheltered from winds from all other directions. Considering the site access difficulties and the fact that this site not very well exposed Davis Inlet may not be very suitable for a WECS installation.

.3 Postville

Postville rests on the shores of Kaipokok Bay at geographic co-ordinates Lat. 54° 54' N, Long. 59° 47' W. A relatively new community, Postville has a population of 223. The major economic activities include fishing during the summer along with sealing, hunting and trapping during other seasons. Access to the community is by air and sea only. The carriers, Labrador Airways and CN coastal boats, run scheduled services to Postville.

Postville has four diesel generators, three 75 kW and one 50 kW machine. The Hydro plant is located at the southern end of town.

3.2 SITE DESCRIPTIONS (Cont'd)

.3 Postville (Cont'd)

The topography surrounding Postville is hilly with areas of swamp and bog. The land slopes upward from the shoreline and meets a 40 m ridge which runs to the west of town in a NE-SW direction. The highest point of land within 1 km of the village is an eighty-three m hill 750 m to the west of the power plant (Figure 3.5). There is no existing access to this site, however, the terrain does not preclude the construction of an access road.

The nearest weather station to Postville is located at Hopedale. The winds are westerly with an average annual speed of 20.8 km per our at this station.

.4 Makkovik

Built on the west shore of Makkovik Harbour at geographic co-ordinates 55° 05' N, 59° 10' W Makkovik has a population of 347. Fishing, hunting and trapping appear to be the chief economic activities of the town. Labrador Airways and CN coastal boats provide access to the community on a scheduled basis.

Electrical characteristics of the community are: 103 kW minimum load, 328 kW peak load and 1692 MWh annual energy consumption. Newfoundland and Labrador Hydro's diesel plant, which houses two 250 kW generators and one 450 kW generator is located towards the south end of town.

The topography of the Makkovik area is generally hilly with some vegetation evident in sheltered areas. Relatively flat ground exists due west of town with unpaved roads constructed through the area to the airport and other nearby facilities. The most promising WECS site is approximately 500 m north west of the community on a hilltop at elevation 94 m (Figure 3.6).

As with Postville the nearest weather station to Makkovik is at Hopedale. The average annual wind velocity is considered adaquate to support WECS and the above mentioned site is exposed to the prevailing winds.

.5 Rigolet

Located on the north shore of Lake Melville at geographic co-ordinates Lat. 54° 10' N, Long. 58° 25' W, Rigolet is a fishing village of 271 people. Other activities such as sealing, hunting and trapping are used to provide income for the inhabitants.

3.2 SITE DESCRIPTIONS (Cont'd)

.5 Rigolet (Cont'd)

There is access to Rigolet via Labrador Airways and the CN coastal boats.

Electricity is provided by an independent diesel system operated by NLH. Four generators, two 250 kW units and one each of 134 kW and 60 kW supply the village. The plant is located 100 m north of the airplane dock.

The topography of Rigolet and the surrounding area is one of gentle slopes which increases in height as they radiate outward from the village. The nearest high point of land is Sunday Hill which is 117.5 m above sea level and a distance of 1.3 km from the power plant. (Figure 3.7). This is a long distance to run a power line and an access trail. If this is the only potential site in the area it could prove to be uneconomical to install a WECS this distance from the village.

.6 Paradise River

Paradise River, a community of 92 inhabitants, is located at geographic co-ordinates 53° 39' N, 57° 15 W. Fishing, hunting and trapping are the activities which form the economic base of the community. Access by air and sea only.

Newfoundland and Labrador Hydro operate the diesel plant which serves Paradise River. The plant, located in the middle of town has an installed capacity of 140 kW consisting of two 40 kW units and one 60 kW unit. The community load characteristics are a minimum load of 21 kW, a peak load of 73 kW and an annual energy consumption of 212 MWh.

The land slopes upward to the north from the shore of Paradise River and continues to rise as distance from the river increases. The best potential WECS site is 550 m northwest of the diesel plant at elevation 76.3 m but will require extensive access route construction as will any site in this area (Figure 3.8).

Cartwright has the nearest weather station to Paradise River. At Cartwright the average annual wind speed is 20 km/hr and is generally from the west. The windfield at Paradise River is therefore considered adaquate to support a WECS.

3.2 SITE DESCRIPTION (Cont'd)

.7 Cartwright

Cartwright is an incorporated community located on the coast of Labrador at geographic co-ordinates Lat. 53° 42' N, Long. 57° 01' W. The 658 residents of the community earn their living from the fishery and more recently from the spin-offs of offshore oil and gas, the boat building industry and the increasing emphasis of Cartwright as a regional centre.

Access to the community is available by boat, fixed wing aircraft and helicopter. Labrador Airways and the CN Coastal boats operate a scheduled service to Cartwright.

Electricity in the community is provided by an independent diesel generating system. The system consists of 3 generators, two - 300 kW and one - 250 kW units. The plant is owned and operated by NLH. The load characteristics for Cartwright are a minimum load of 168 kW, a maximum load of 492 kW and an average annual energy consumption of 1749 MWh.

The Atmospheric Environment Service maintains a weather station at Cartwright. The mean annual wind speed at Cartwright is 20 km/h. with the prevailing winds being westerly.

A hilltop at elevation 40 m approximately 400 m north of Cartwright has the best potential for supporting a WECS installation. Access to this site is via an existing road which may require minor upgrading. Figure 3.9 shows the general layout of the community of Cartwright and a cross section of the proposed site.

.8 Black Tickle

Located at geographic co-ordinates Lat. 53° 28' N, Long. 55° 45' W, Black Tickle is an incorporated fishing village with a population of 194. The community is built on the shoreline of Salmon Bight which opens to the east to the Labrador Sea. Houses are scattered haphazardly along the only road in the village, which is unpaved and follows the shoreline of Salmon Bight.

Access to the community is limited to either boat or helicopter or float equipped aircraft.

3.2 SITE DESCRIPTIONS (Cont'd)

.8 Black Tickle (Cont'd)

Electrical power in Black Tickle is provided by three diesel generators, two 300 kW machines and one 250 kW generators. The plant is owned and operated by Newfoundland and Labrador Hydro (NLH). The diesel plant is located on the west side of Salmon Bight approximately 100 m north of the Transport Dock (Figure 3.10). The minimum load, peak load and annual energy consumption are 75 kW, 120 kW and 858 MWh respectively.

The wind data for this area is sparse with the nearest weather station being located at Cartwright some 75 km to the north west. Based on this data it could be expected that the prevailing winds will be westerly with an average annual velocity of 20 km per hour.

The topography surroundings Black Tickle is rolling hills with heights up to 75 m within 1 km of the village. A hill 200 m east of the community is considered the most feasible WECS site (Figure 3.10) as access to other sites in the vicinity would be very difficult. This site, however, may be too close of occupied houses.

.9 Charlottetown

Charlottetown is situated on the south side of White Bear Arm at geographic co-ordinates 52° 46' N 56° 07' W. The community population of 250 earn their living from fishing, hunting and trapping as is the case in many coastal Labrador communities.

CN Marine coastal boats and Labrador Airways provide access to the community. The diesel plant located at the west end of the town is operated by NLH and contains two 136 kW units and one 60 kW unit. Community load characteristics are a minimum load of 30 kW, a peak load of 156 kW and an annual energy consumption of 456 MWh.

The land in the general area of Charlottetown slopes upward from White Bear Arm. To the southwest the land is generally flat with ponds of varying size. West of the town hills up to 100 m high shelter the town. The WECS site with the best potential is 750 m west of the community on a hilltop at elevation 93.2 m (Figure 3.11).

3.2 SITE DESCRIPTIONS (Cont'd)

.9 Charlottetown (Cont'd)

Battle Harbour has the nearest weather station to Charlottetown. The average annual wind speed at Battle Harbour is 26.7 km/h and the prevailing direction being westerly. In view of the prevailing wind direction Charlottetown is not considered to be a good location for a WECS as any site near the town is in the lee of surrounding hills.

.10 Williams Harbour

Located at geographic co-ordinates 52° 33' N, 55° 46' W. Williams Harbour is a small community of 78 inhabitants. The fishery comprises the main economic support for the community with hunting and trapping contributing a small amount.

Access is via the CN coastal boat service and at times Labrador Airways. Two 136 kW and one 60 kW generators operated by NLH provide power to Williams Harbour. The load characteristics are a minimum load of 30 kW, a peak load of 90 kW and an annual energy consumption of 320 MWh.

Williams Harbour is on Granby Island with two other small communities; George's Cove and Kings Cove. Granby Island is generally hilly with elevations up to 140 m above sea level. A hilltop 400 m east of the town at elevation 93 m is considered the most suitable site (Figure 3.12) but is it surrounded by higher features within a 10 km radius with some higher points as close as 1.5 km.

The closest weather station to Williams Harbour is at Battle Harbour. The average annual wind speed at Battle Harbour is 26.7 km/h and the prevailing direction is westerly which is consistent with the rest of the Labrador coast.

It can therefore, be concluded that the windfield at Williams Harbour is adaquate to support a WECS but may be too turbulent due to the surrounding topography.

.11 Port Hope Simpson

Port Hope Simpson, a community of population 581, is located at geographic co-ordinates 52° 32' N, 56° 18' W. Due to the lack of responses to the questionnaire and the fact that the town lies inland from the sea the main economic activity is not known but is very likely fishing, hunting and trapping. A sawmill operation also exists in this area.

3.2 SITE DESCRIPTIONS (Cont'd)

.11 Port Hope Simpson (Cont'd)

Access to Port Hope Simpson is via Labrador Airways on CN coastal boat depending on the season. NLH operates the diesel plant located south east of the community. The diesel plant contains two 250 kW generators and one 136 kW generator. Load characteristics of the community are a minimum load of 30 kW a peak load of 306 kW and an annual energy consumption of 904 MWh.

The land surrounding Port Hope Simpson slopes upwards from the Alexis River to elevations in excess of 230 m. A suitable site for a WECS is 900 m due south of the diesel plant (Figure 3.13) on a hilltop at elevation 100 m. A cart track passes near the summit of the hill so access road construction would not present an insurmountable obstacle.

Battle Harbour has the closest weather station to Port Hope Simpson. Based on the information from Battle Harbour it can be assumed that the windfield in this area is adaquate but the problem of wind turbulence created by surrounding higher topograhical features may perclude Port Hope Simpson as a viable WECS site.

.12 Saint Lewis

Located at geographic co-ordinates 52^{o} 22' N, 55^{o} 41' W Saint Lewis has a population of 280. The economy of Saint Lewis is based on the fishery. Scattered around the shores of Fox Harbour the community has a well developed road network.

Access to Saint Lewis is by Labrador Airways and CN coastal boats. Dock facilities suitable for unloading and loading heavy equipment and supplies are present in Saint Lewis.

The diesel plant operated by NLH is on the west side of Fox Harbour. It houses two 136 kW units, one 220 kW unit and one 75 kW unit. Community load characteristics are a minimum load of 50 kW a peak load of 261 kW and an annual energy consumption of 833 MWh.

The terrain surround Saint Lewis is hilly with some hilltops at elevation 120 m above sea level. A hilltop 1 km east of the community at elevation 122 m+ (Figure 3.14) is the best site for a WECS in the area of Saint Lewis. This hilltop is exposed to wind from all directions and is accessible by an existing road. Connection to the community grid would also be a simple matter as the power distribution line follows the access road.

3.2 SITE DESCRIPTIONS (Cont'd)

.12 Saint Lewis (Cont'd)

Saint Lewis is less than 20 km away from Battle Harbour, the nearest weather station. Favourable wind conditions exist at Battle Harbour and due to the short distance separating the two communities it is concluded that similar conditions exist in Saint Lewis.

.13 Mary's Harbour

Mary's Harbour has a population of 408 and is located in Southeastern Labrador at geographic co-ordinates Lat. 52° 19' N, Long. 55° 49' W. The Town is laid out around the shore of the harbour. At present the fishery is the mainstay of the economy, with summer migrations to the fishery stations located along the coast.

Access to Mary's Harbour is by CN coastal boat or Labrador Airways. With the availability of the air-strip Mary's Harbour could become the administration center for the region.

The power plant is located at the north western end of the community. The generating plant also services the community of Lodge Bay. There are three generators in the plant, two of 250 kW and one of 300 kW. See Table 3.3 for electrical generation summary.

The topography surrounding Mary's Harbour is mostly low hills with the land being generally of greater elevation, the greater the distance from the town. The terrain is rugged and fairly complex but it is small scale terrain none the less. A suitable WECS location is on a hilltop 600 m north of the community at elevation 71.0 m (Figure 3.15). It is possible, however, that EMI may make this site unsuitable.

The nearest weather station is at Battle Harbour. Based on this data there does not appear to be a prevailing wind. The direction with the highest frequency of occurance and the highest velocities are south for 13.0% at 33 km/h and north for 9.8% at 33 km/h. The wind blows from westerly directions 51.6% of the time so in a broad sense it could be said that the prevailing winds are westerly. Since this is the case at all the other weather stations on the Labrador coast it could be expected that a similar situation exists in Mary's Harbour.

3.2 SITE DESCRIPTIONS (Cont'd)

.14 L'Anse au Loup

L'Anse au Loup is located in the Strait of Belle Isle at geographic co-ordinates 51° 32' N 56° 50' W. A road connects L'Anse au Loup with six other communities stretching from Blanc Sablon to Red Bay.

Access to L'Anse au Loup is via a ferry which connects Blanc Sablon with Flowers Cove on the Great Northern Peninsula. Labrador Airways also flies into this area.

Newfoundland and Labrador Hydro operate the diesel plant located in L'Anse au Loup which serves seven communities between L'Anse au Clair and Red Bay with a total population of 2000 +. The plant houses one 1100 kW unit, one 800 kW unit and two 600 kW units. Load characteristics for this plant are a minimum load of 380 kW, a peak load of 1728 kW and an annual energy consumption of 6,973 MWh.

The land in the area of L'Anse au Loup rises from the shoreline and tends to increase in height as distance from the shore increases. A suitable site for a WECS is approximately 3 km north east of L'Anse au Loup along the road connecting the above mentioned communites (Figure 3.16). This site is open to the prevailing westerly winds. Siting a WECS for the L'Anse au Loup power system, however, warrants more research due to the fact that it could be sited anywhere from L'Anse au Clair to Red Bay.

St. Anthony has the closest weather station to L'Anse au Loup. In fact three weather stations exist at St. Anthony and all measure an average annual wind speed of greater than 20 km/h. The prevailing winds at St. Anthony are westerly which is consistent with coastal Labrador stations. It is, therefore, assumed that the windfield in the L'Anse au Loup area is adaquate to support a WECS installation.

3.3 SITE ASSESSMENT AND SELECTION

The assessment of each site is based on all the information collected during the study period including that gathered with the questionnaire and during telephone conversations with community residents. This information was then compiled for each community and the evaluation matrix (Table 3.2) derived.

3.3 SITE ASSESSMENT AND SELECTION (Cont'd)

The following is a brief summary of the evaluation by criteria.

.1 Windfield

Based on the questionnaire results and AES data, the windfield in all communities would appear to meet or exceed the 20 KMh guideline. Of the total questionnaire responses 91% indicated that the wind blows harder than 70 km/h two to three times a week. 60% said the wind velocity exceeds 70 km/h most every day. If the estimates were reduced to 35 km/h to compensated for exaggeration by respondents the wind speed would still be adaquate for WECS operation. All communities received a yes for windfield, however, long term monitoring is obviously required to verify this

.2 Topography

The topography surrounding all communities is rugged with hills up to 100 m high present adjacent to most communities. Communities which received a no rating for topography were Postville, Charlottetown, William's Harbour and Port Hope Simpson. The potential WECS sites in the above communities are sheltered from the prevailing winds or surrounded by higher features which create a potential for high turbulence.

Nain, Davis Inlet, Paradise River and Black Tickle received a rating of 10 for topography. These communities are exposed to prevailing winds but the potential sites are blocked by higher features in other directions. A twenty point rating was scored by the remaining communities which have potential sites exposed to the wind from all directions but some features within 10 km are higher. No potential WECS site was awarded the top score of 30 points because such sites were too remote from the communities.

.3 Safety

Safety distance was met by all sites except for the site at Black Tickle. Other potential sites exist in the area of Black Tickle but were either too remote from the town or would require very extensive access road construction of near 700 m in length through very rough terrain.

3.3 SITE ASSESSMENT AND SELECTION (Cont'd)

.4 Icing

Respondents to the questionnaire indicated that freezing rain occurs 10 times per year in most of the communities. These occurances, which would tend to be the worst cases experienced during a year, result in ice accumulations of approximately 13 mm. This type of ice accumulation is not severe enough to disqualify a site.

In the case of Makkovik, however, questionnaire respondents, including one individual who previously operated a wind charger, said that freezing rain occured up to 20 times per year with accumulations in excess of 25 mm. In comparison with other sites this ice accumulation is quite high and this may be a potential problem.

All communities except Makkovik are weighed equally. It is obvious that this criterion will remain largely an unknown until ice acretion instrumentation is installed at specific sites.

.5 Geology

The geology of all the communities was very consistent, usually comprising exposed bedrock or bedrock thinly covered with peat or shrubs. Occasionally tree growth was noted on the slopes of some sites, most notably at Port Hope Simpson.

.6 Skills and Equipment

Of the eleven communities that responded to the questionnaire eight have some construction equipment, usually a small backhoe and truck. In most cases the equipment is controlled by the town councils. Importing equipment into some of the communities to erect WECS may create some logistics problems due to the lack of adaquate dock facilities.

Aquiring an adaquate workforce in some of the smaller communities may also present a problem. Some of the relevant skills required to erect a WECS may not be available in each town. This problem, however, is not considered prohibitive to erecting a WECS as skills can be imported to remote areas.

3.3 SITE ASSESSMENT AND SELECTION (Cont'd)

.7 Site Access

The most consistent problem encountered with the WECS sites is the difficulty of access only. Cartwright and Saint Lewis are the only communities which will not require extensive access road construction. The rest will require either the construction of an access road through difficult terrain or use of a helicopter to lift the equipment to the site.

.8 Social Impacts

Ten negative social impacts have been noted during conversations with community members or on the questionnaires. A resident of Paradise River did object to a WECS being placed in his community and expressed concern that "environmental damage in the construction process could be severe and would have to be consciously minimized". For the most part community residents hoped that a WECS installation would lower their power bills.

.9 Acquisition

Every site chosen is assumed to be on crown land so acquisition for a WECS installation will not present a problem.

.10 Demonstration Visibility

Demonstration visibility will be best in L'Anse au Loup where the population served by the diesel plant is approximately 2000 people.

.11 EMI

Electromagnetic interference is not expected to be a problem as most sites are out of the direct line of transmisssion. This, however, will require further research because the transmitter location map in Appendix B may not be entirely accurate.

.12 Connection Distance

The connection distance to WECS sites is, in general, less than 1 km with most sites being 400 - 700 m from the power lines. Only Rigolet had a potential WECS site identified at greater than 1 km.

3.3 SITE ASSESSMENT AND SELECTION (Cont'd)

.13 Minimum Demand

The minimum demand for Labrador coastal communities ranged from 21 kW at Paradise River to a high of 380 kW at L'Anse au Loup with most communities falling in the range between 30 kW and 100 kW. In some of the communities with the smaller minimum loads the selection of WECS to achieve allowable penetrations although is limited, however, certainly possible.

When the above criteria were appropriately weighted and entered on the evaluation matrix (Table 3.2), the individual communities scored in the following order:

Cartwright	115 points
L'Anse au Loup	115 points
Makkovik	105 points
Saint Lewis	105 points
Mary's Harbour	95 points
Nain	85 points
Rigolet	85 points
Paradise River	80 points
Davis Inlet	75 points

As previously stated Makkovik may prove to an unsuitable site due to icing problems, but because of its otherwise high weighting it is included in the list of suitable sites. The only suitable site at Mary's Harbour suffers from EMI which makes it a poor location for a WECS. Rigolet has a suitable WECS site 1.3 km from the powerhouse which is beyond the recommended maximum connection distance. Also considered a poor site is Davis Inlet due to a number of factors, not the least of which is access. This shortens the list of suitable communities to the following:

Cartwright	115 points
L'Anse au Loup	115 points
Makkovik	105 points
Saint Lewis	105 points
Nain	85 points
Paradise River	80 points

These six communities are recommended as the sites to be used for the preliminary selection of WECS installations in coastal Labrador.

TABLE 3.1

SUMMARY OF QUESTIONNAIRE RESULTS

Question Topics	Nain	Davis Inlet **	Postville	Nakkovik	Rigolet	Paradise River	Cartwright	Black Tickle	Charolettetown
Wind									
Prevailing Direction(s) (S-W)*	East - West		West - West	West - West	West - West	N-West - N-West	S-West - N-West	South - North	S-East - N-East
Speed	>70 km/hr		> 70 km/hr	> 70 km/hr		> 70 km/hr	> 70 km/hr	> 70 km/hr	> 70 km/hr
Freq.	2-3 days/wk		most every day	most every day	2-3 days/wk	2-3 days/wk	most every day	most every day	once a week
Freezing Rain									
Freq. (Per Year)	2		5 - 10	10 - 20	4 - 8	5 - 10	5	8	10
Months of Occurance	Mar, May, Nov, Dec,		Jan, Feb, Mar, Apr, Oct, Nov, Dec,	Jan, Feb, Mar, Apr, May, Oct, Nov, Dec,	Jan, Feb, Mar, Apr, Oct, Nov Dec,	Jan, Feb, Mar, Apr, Oct, Nov, Dec,	Jan, Feb, Mar, Apr, Nov, Dec,	Jan, Feb, Mar Apr, Nov, Dec,	Jan, Feb, Mar, Nov, Dec,
Thickest Accumulation Observed	6 mm		25 mm	> 25 mm	13 mm	19 mm	13 mm	13 mm	25 mm
Thunder Storms									
No. per Year	2 - 3		> 3	> 3	> 3	1 per Year	2 - 3	2 - 3	2 - 3
Site Selection	Northern Point; Top of Main Hill		North West of Power Plant	Airport Road Top of Main Hill	Sunday Hill	Hills Beside Road to Airstrip	Hill North of Community	Northeast of Community	Hill Top to North
Assessment of Site Recommended by Residents Good, Poor			Good				Good	Good	Poor
Community Impact									
Perceived community Benefits	Cheaper Power		Cheaper Power	Cheaper Power	Cheaper Power		Cheaper Power	Cheaper Power	
Heavy Equip.	Yes		Yes	Yes	Yes	Yes	Yes	No	
Objections	No		Would not operate - don't have wind energy	No	No	Yes	No	No	
Comments	Nil		Nil	Operated Wind Charger for 4 Years	Suggest Solar or tidal as alternate energy sources	Possible Environ. Damage	Most Helpful During Winter	Nil	Nil

* S-W Summer - Winter

** No questionnaires returned from these communities.

TABLE 3.1 (Cont'd)

SUMMARY OF QUESTIONNAIRE RESULTS (Cont'd)

Question Topics	William's ** Harbour	Port Hope ** Simpson	Saint Lewis	Mary's Harbour	L'Anse au Loup				
Wind									
Prevailing Direction(s) (S-W)*	(1) West - West		South - North	N-West - North	West - N-West				
Speed	>70 km/hr		> 70 km/hr	> 70 km/hr	> 70 km/hr				
Freq.	Most every day		Most every day	Most every day	Most every day				
Freezing Rain									
Freq. (Per Yr.)			4 - 6	15	1 - 2				
Months of Occurance			Mar, Apr, May Oct, Nov,	Jan, Feb, Mar, Nov, Dec,	Jan, Dec,				
Thickest Accumulation Observed			13 mm	13 mm	25 mm				
Tunder Storms No. per Year			2 - 3	> 3	2 - 3				
Site Selection	West of Community	South of Dock	North East of Community near CBC Tower	North West of Community	2 km East of Community				
Assessment of Site Recommended by Residents Good, Poor	Poor	Poor	Good	Poor	Poor				
Community Impact									
Perceived Community Benefits			Cheaper Power	Cheaper Power					
Heavy Equip.			No	Yes	Yes				
Objections			No	No	No				
Comments			Nil	Nil					

* S-W Summer - Winter

** No questionnaires returned from these communities.

(1) Assumed from Battle Harbour data.

EVALUATION MATRIX

PRELIMINARY ASSESSMENT

TABLE 3.2

Weighting Categories	Wind Field	Topo-graphy	Safety	Icing	Soils & Geology	Skill & Equipment	Access	Social Impacts	Acquisition	Demo Visibility	EMI	Connection Distance	Min. Demand	Total
Max Weight	Yes/No	Yes/No/30	Yes/No	15	10	10	25	10	10	5	15	20	15	165
Community														
Nain	Yes	Yes/10	Yes	5	10	10	5	0	10	0	15	5	15	85
David Inlet	Yes	Yes/10	Yes	5	10	5	5	0	10	0	15	10	5	75
Postville	Yes	No												
Makkovik	Yes	Yes/20	Yes	0	10	10	5	10	10	0	15	10	15	105
Rigolet	Yes	Yes/20	Yes	5	10	5	5	10	10	0	10	0	10	85
Paradise River	Yes	Yes/10	Yes	5	10	5	5	5	10	0	15	10	5	80
Cartwright	Yes	Yes/20	Yes	5	10	10	10	10	10	0	10	15	15	115
Black Tickle	Yes	yes/10	No											
Charlottetown	Yes	No												
William's Harbour	Yes	No												
Port Hope Simpson	Yes	No												
Saint Lewis	Yes	Yes/20	Yes	5	10	0	20	0	10	0	10	20	20	105
Mary's Harbour	Yes	Yes/20	Yes	5	10	0	10	5	10	0	0	20	15	95
L'Anse au Loup	Yes	Yes/20	Yes	5	10	10	10	5	10	5	15	10	15	115

TABLE 3.3

COMMUNITY CHARACTERISTICS

Community	Population	Diesel Generator			Load Characteristics			Energy Costs	
		No. of Diesels	Size (kW)	Total Output (kW)	Annual Energy (MWh)	Min. Load (kW)	Peak Load (kW)	O & M Costs $/kwh	Fuel Costs $/kwh
Nain	938	4	3 x 300 1 x 350	1250	2214	131	464	.157	.123
Davis Inlet	240	3	2 x 136 1 x 60	332	604	30	129	.197	.14
Postville	223	4	3 x 75 1 x 50	275	666	36	160	.264	.159
Makkovik	347	3	2 x 250 1 x 450	950	1692	103	328	.14	.15
Rigolet	271	4	2 x 250 1 x 134 1 x 60	696	758	56	200	.235	.124
Paradise River	92	3	2 x 40 1 x 60	140	212	21	73	.47	.193
Cartwright	658	3	2 x 300 1 x 250	850	1749	168	492	.155	.131
Black Tickle	194	3	2 x 300 1 x 250	850	858	75	120	.097	.137
Charlottetown	250	3	2 x 136 1 x 60	332	456	30	156	.257	.138
William's Harbour	78	3	2 x 136 1 x 60	332	320	30	90	.259	.32
Port Hope Simpson	581	3	2 x 250 1 x 136	636	904	30	306	.12	.121
Saint Lewis	283	4	2 x 136 1 x 220 1 x 75	567	833	50	261	.157	.130
Mary's Harbour	204	3	2 x 250 1 x 300	800	1185	90	408	.101	.116
L'Anse au Loup	2000	4	1 x 1100 1 x 800 2 x 600	3100	6973	380	1728	.045	.109

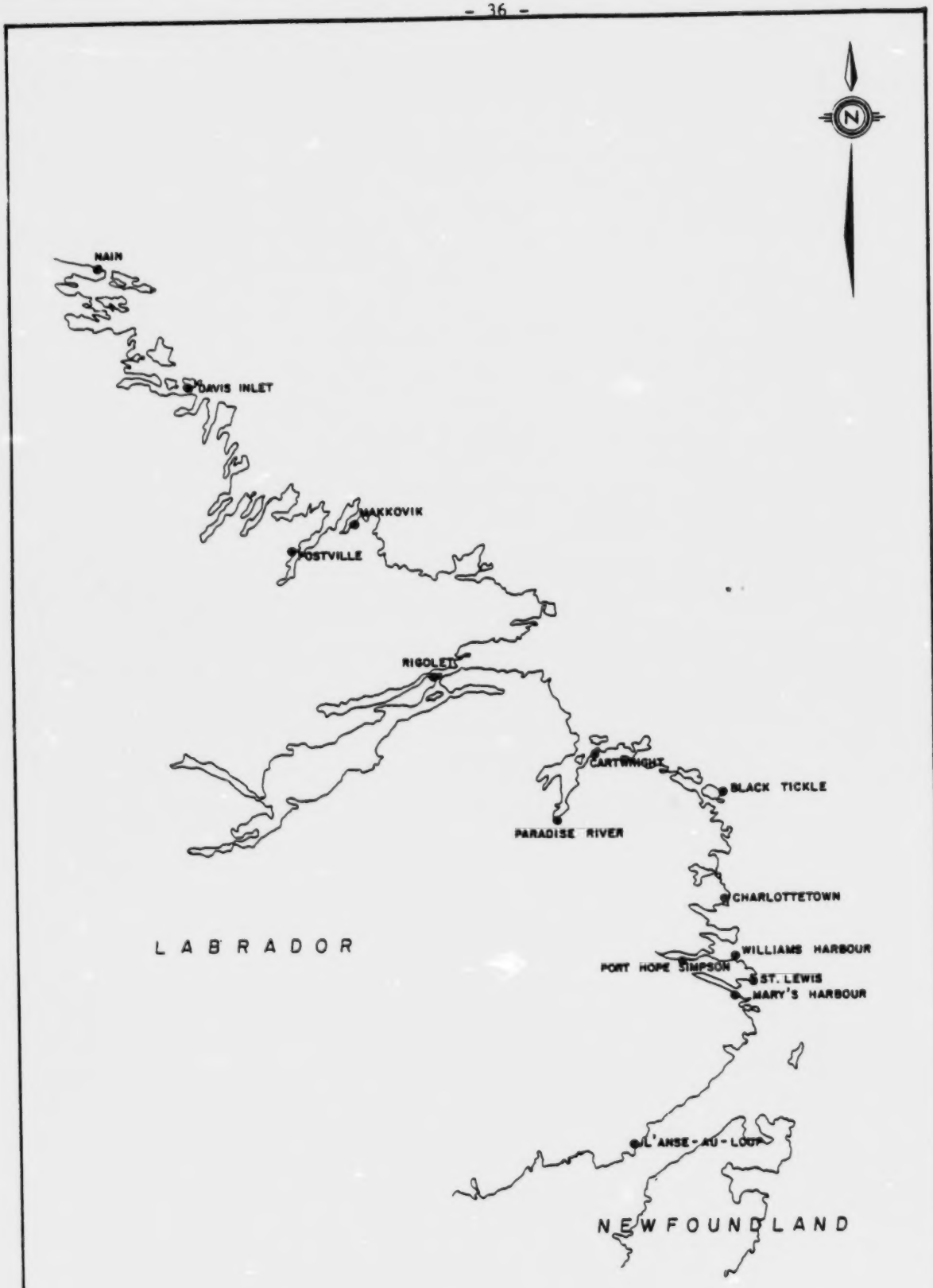


FIGURE 3.1
COMMUNITY LOCATIONS

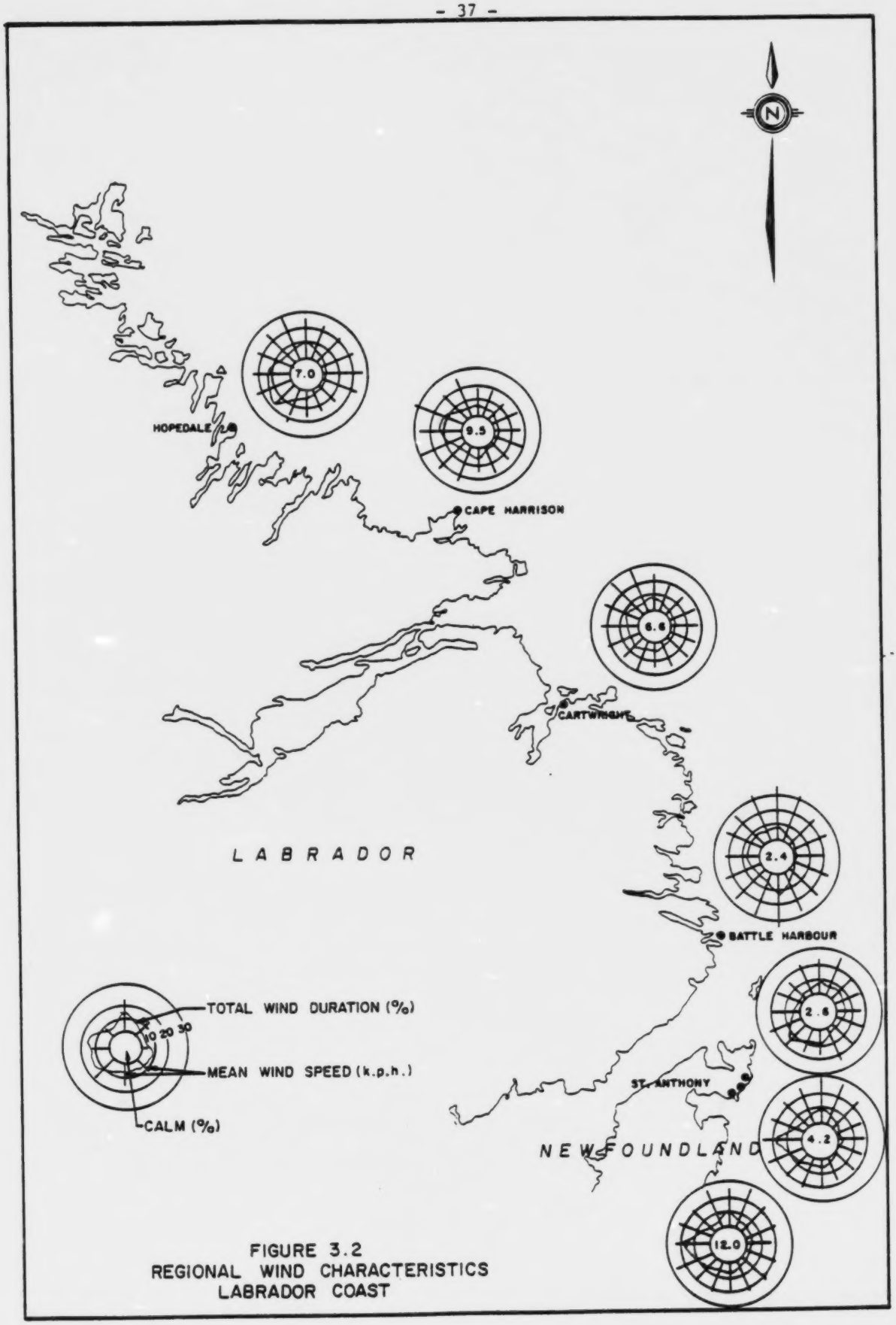


FIGURE 3.2
REGIONAL WIND CHARACTERISTICS
LABRADOR COAST

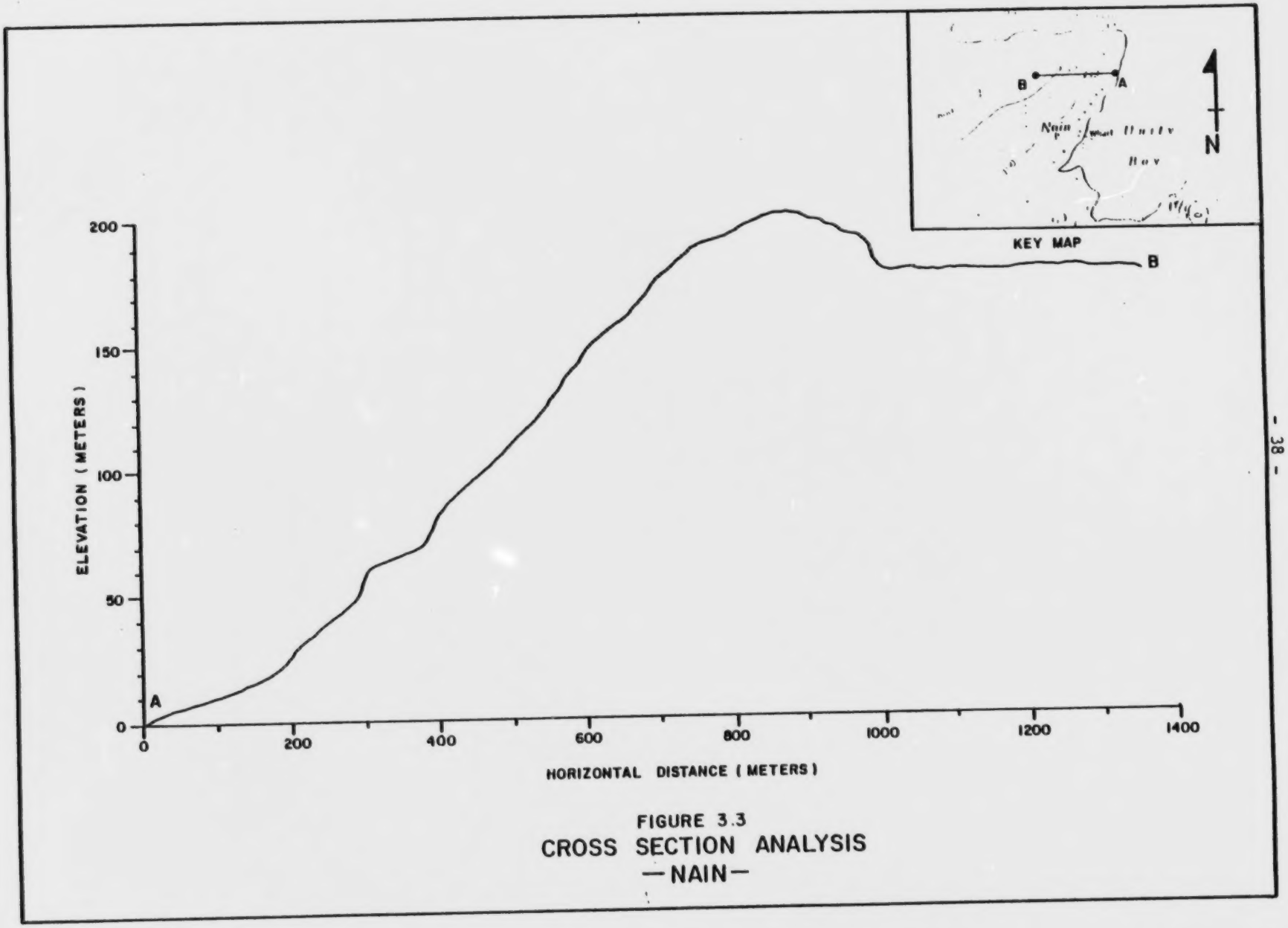
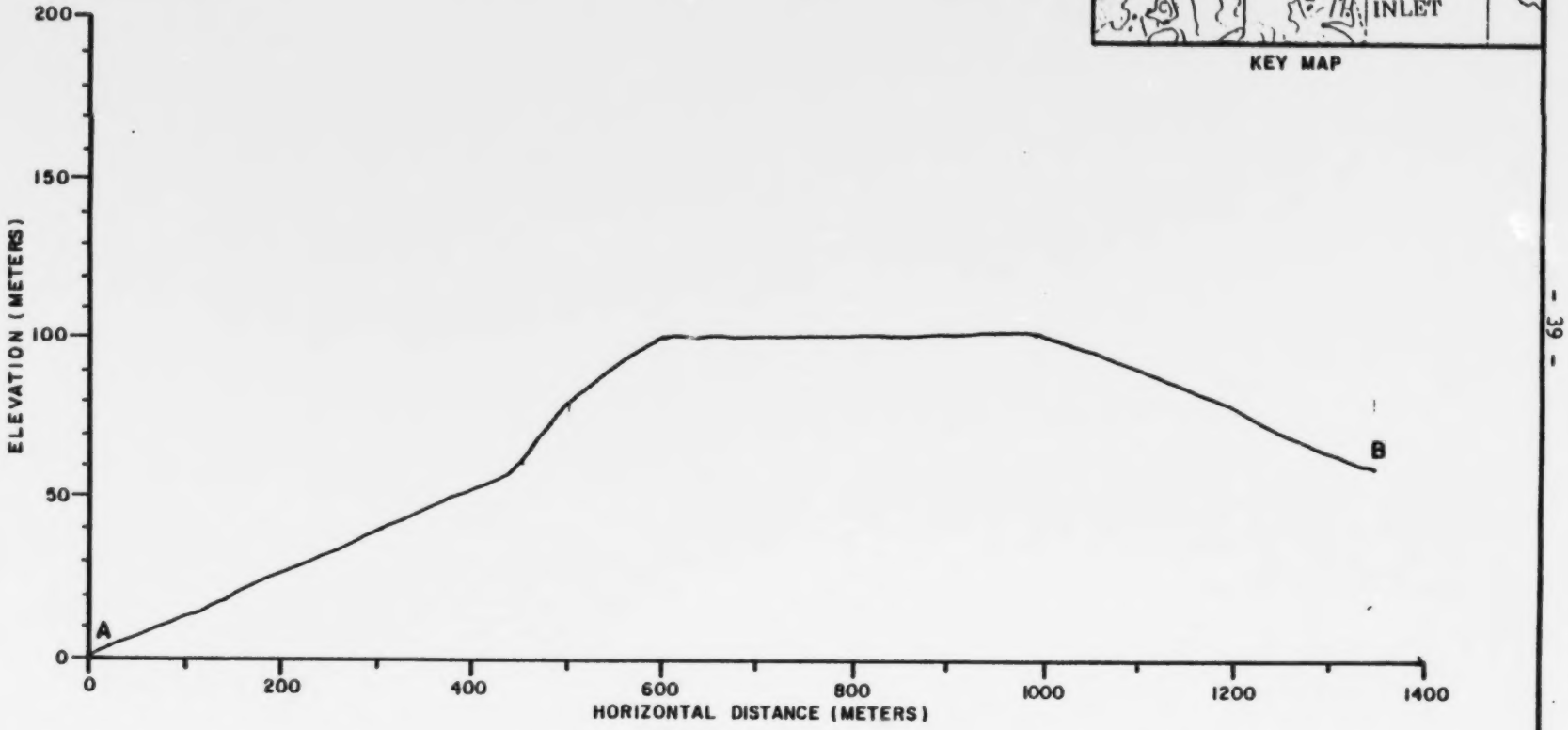


FIGURE 3.3
CROSS SECTION ANALYSIS
— NAIN —



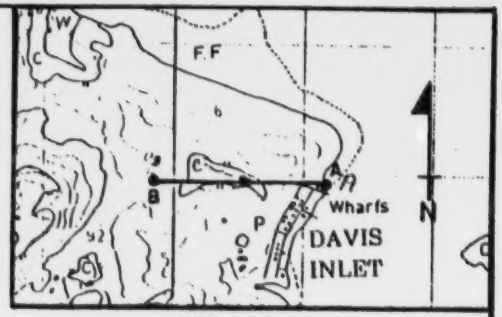
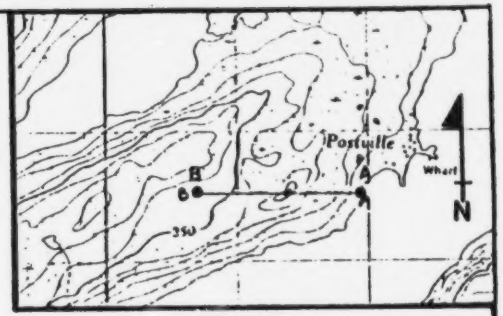


FIGURE 3.4
CROSS SECTION ANALYSIS
—DAVIS INLET—



KEY MAP

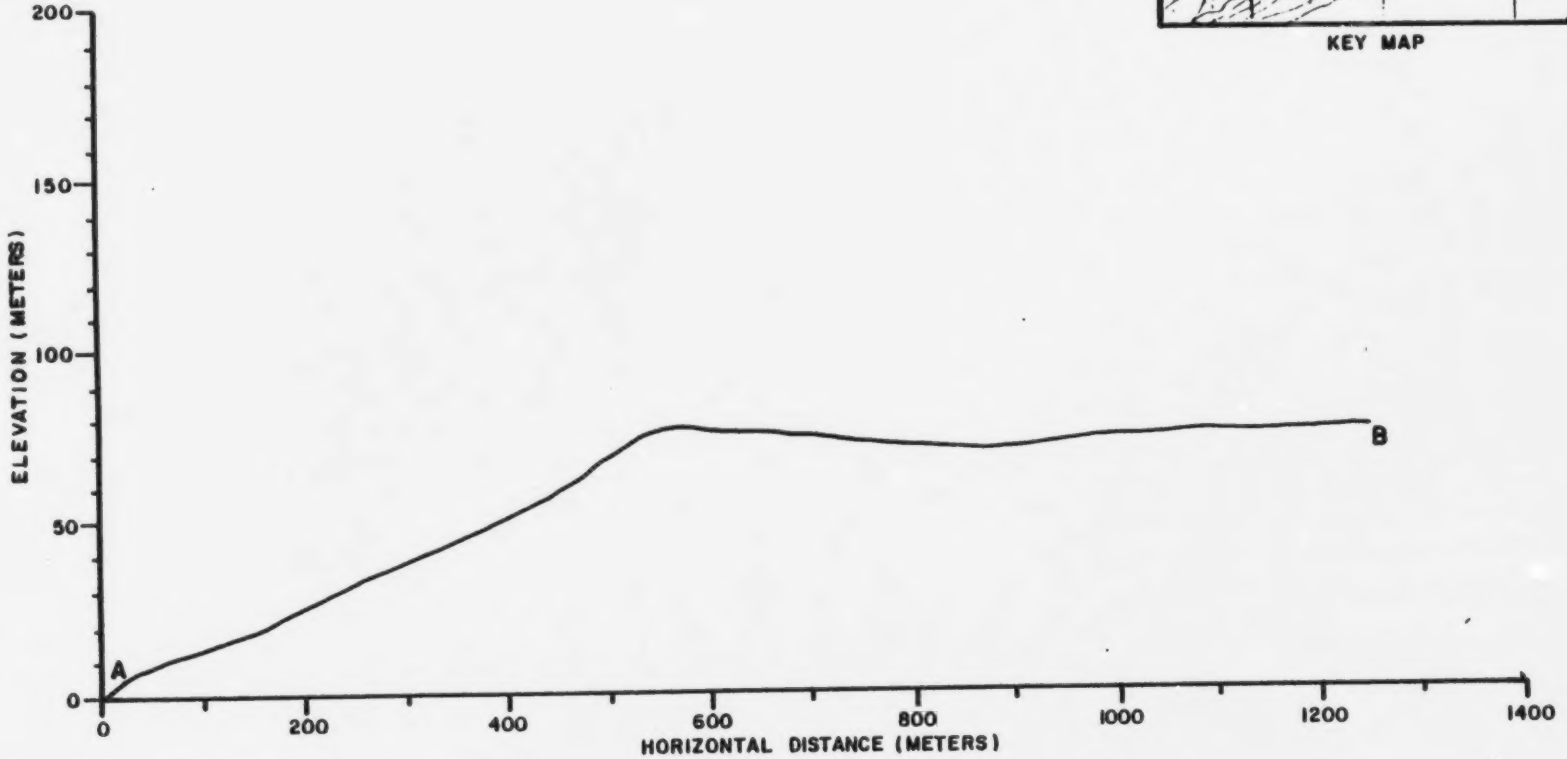
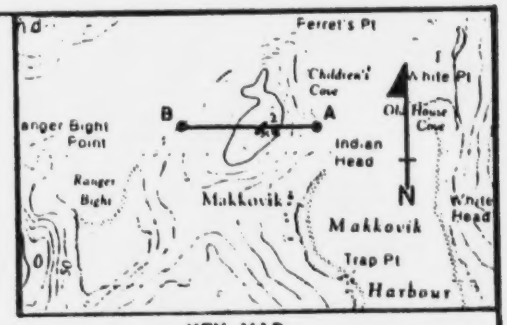


FIGURE 3.5

CROSS SECTION ANALYSIS

—POSTVILLE—



KEY MAP

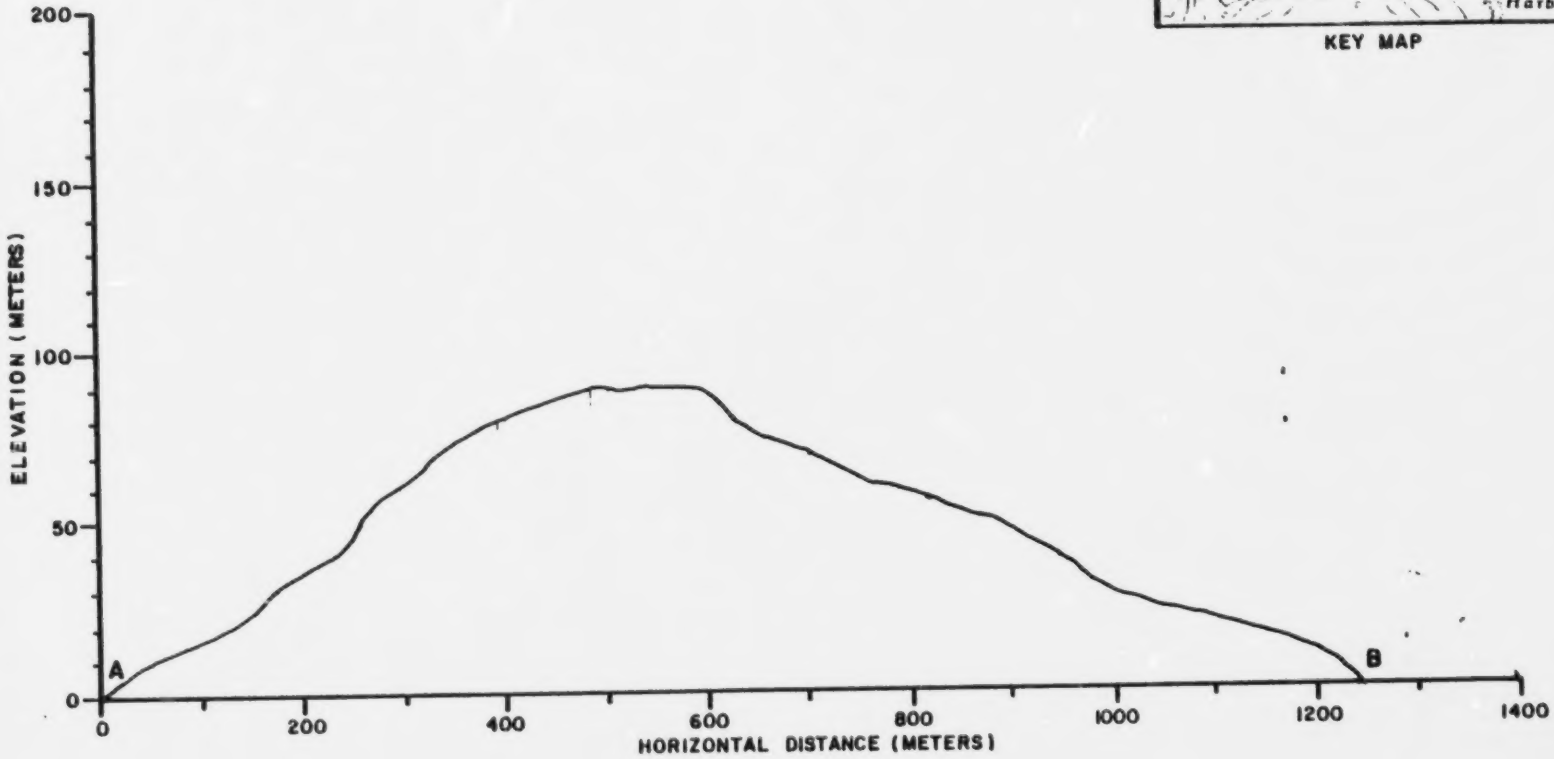
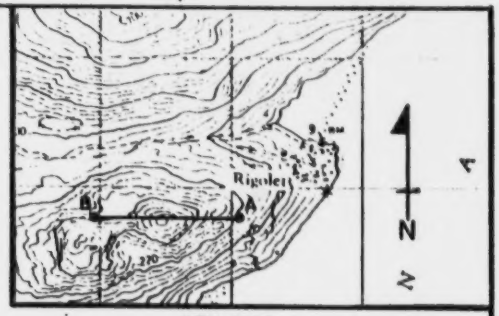


FIGURE 3.6

CROSS SECTION ANALYSIS
—MAKKOVIK—



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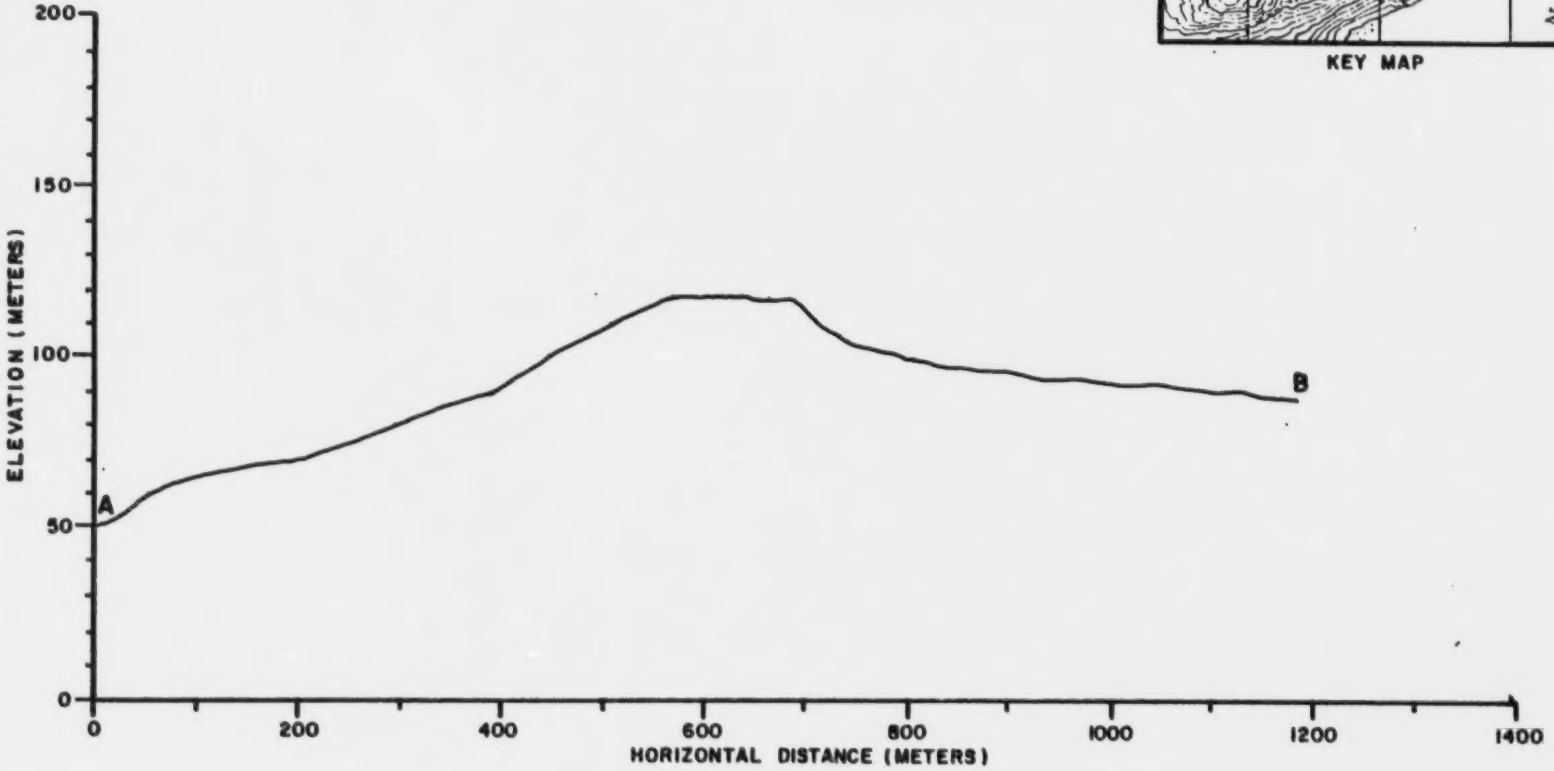
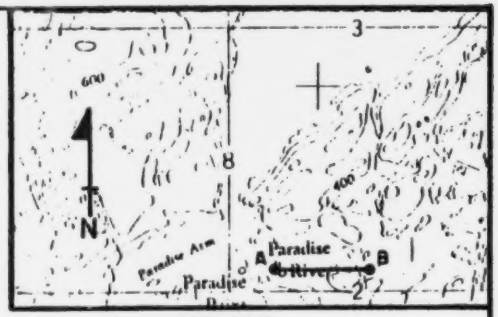


FIGURE 3.7
CROSS SECTION ANALYSIS
—RIGOLET—



KEY MAP

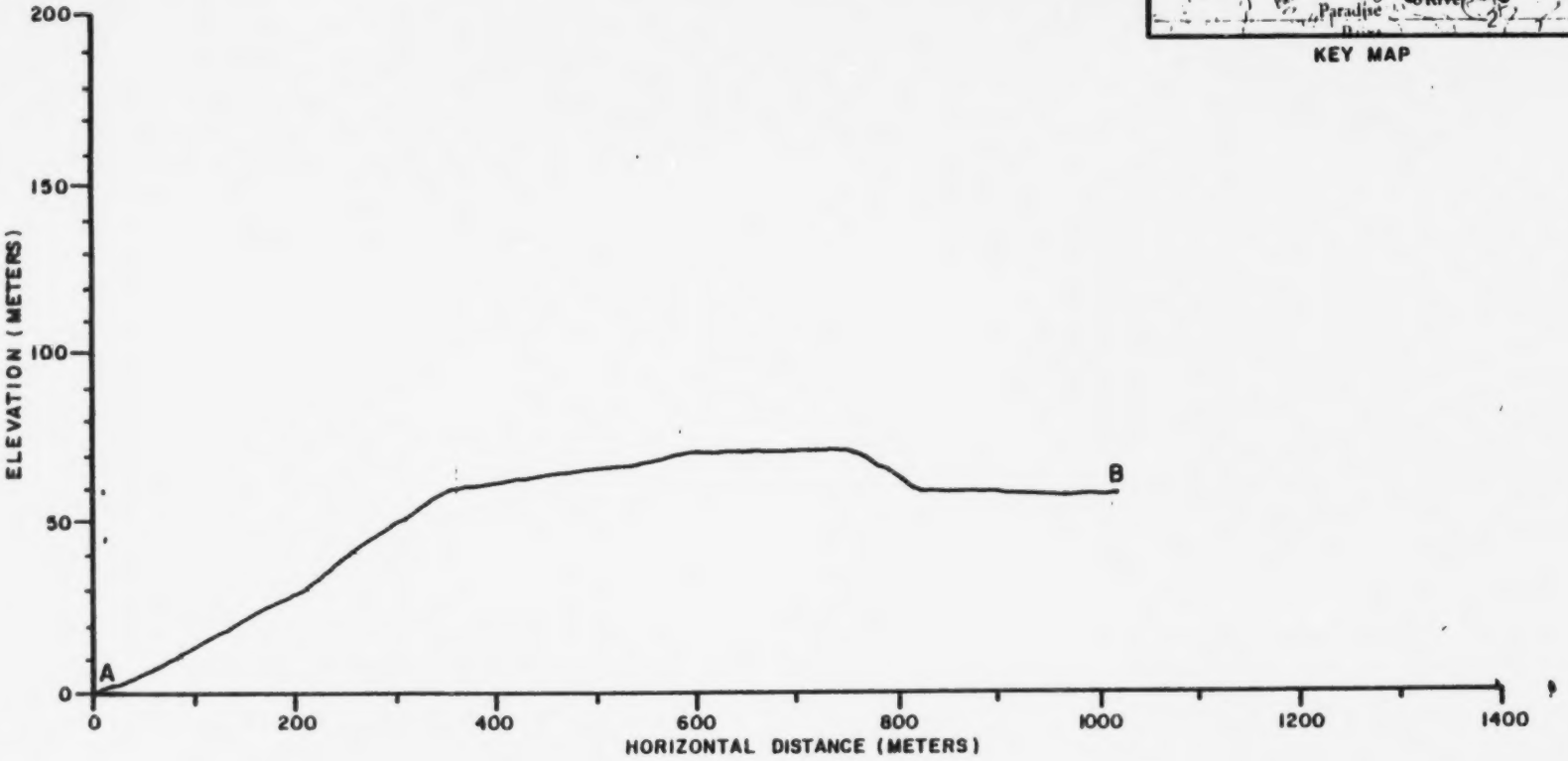
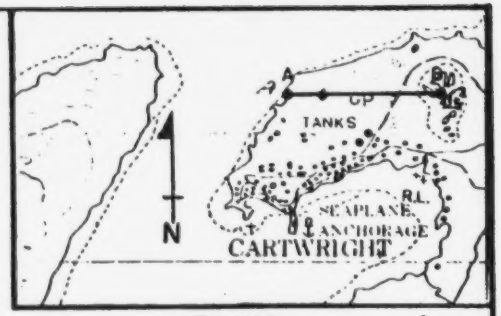


FIGURE 3.8
CROSS SECTION ANALYSIS
—PARADISE RIVER—



KEY MAP

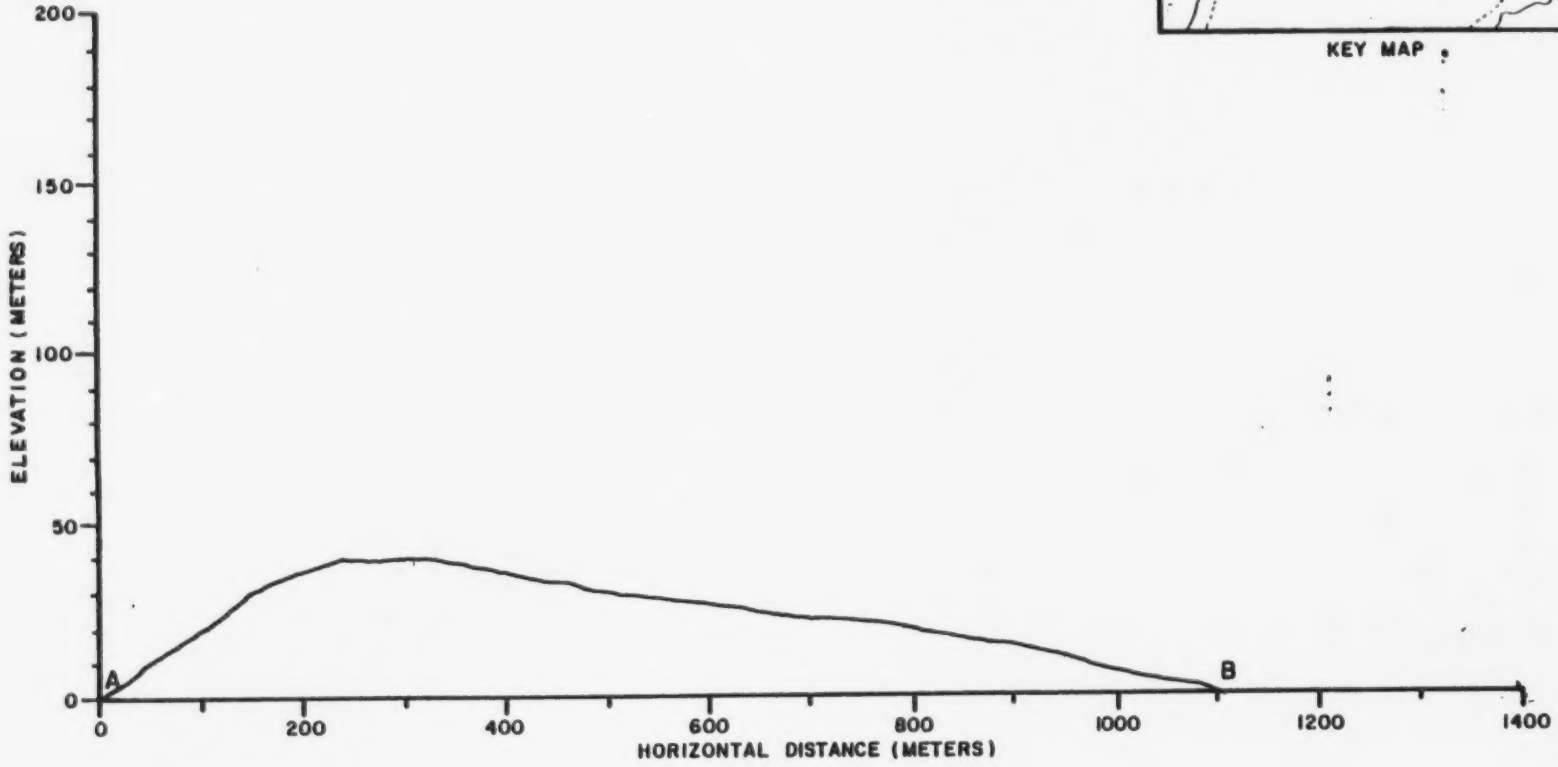
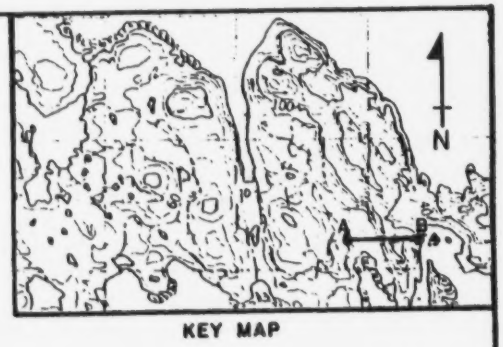


FIGURE 3.9
CROSS SECTION ANALYSIS
—CARTWRIGHT—



KEY MAP

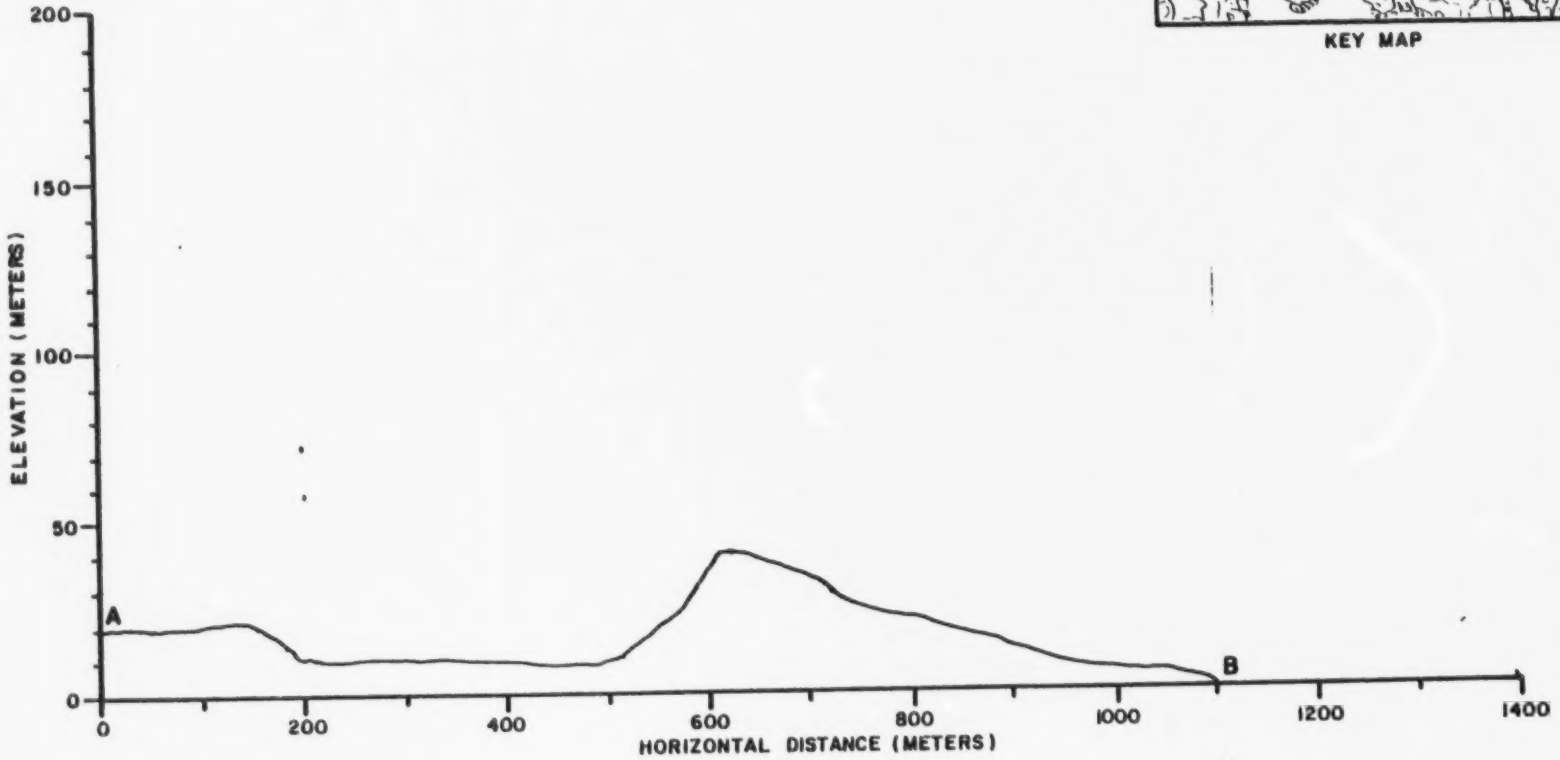
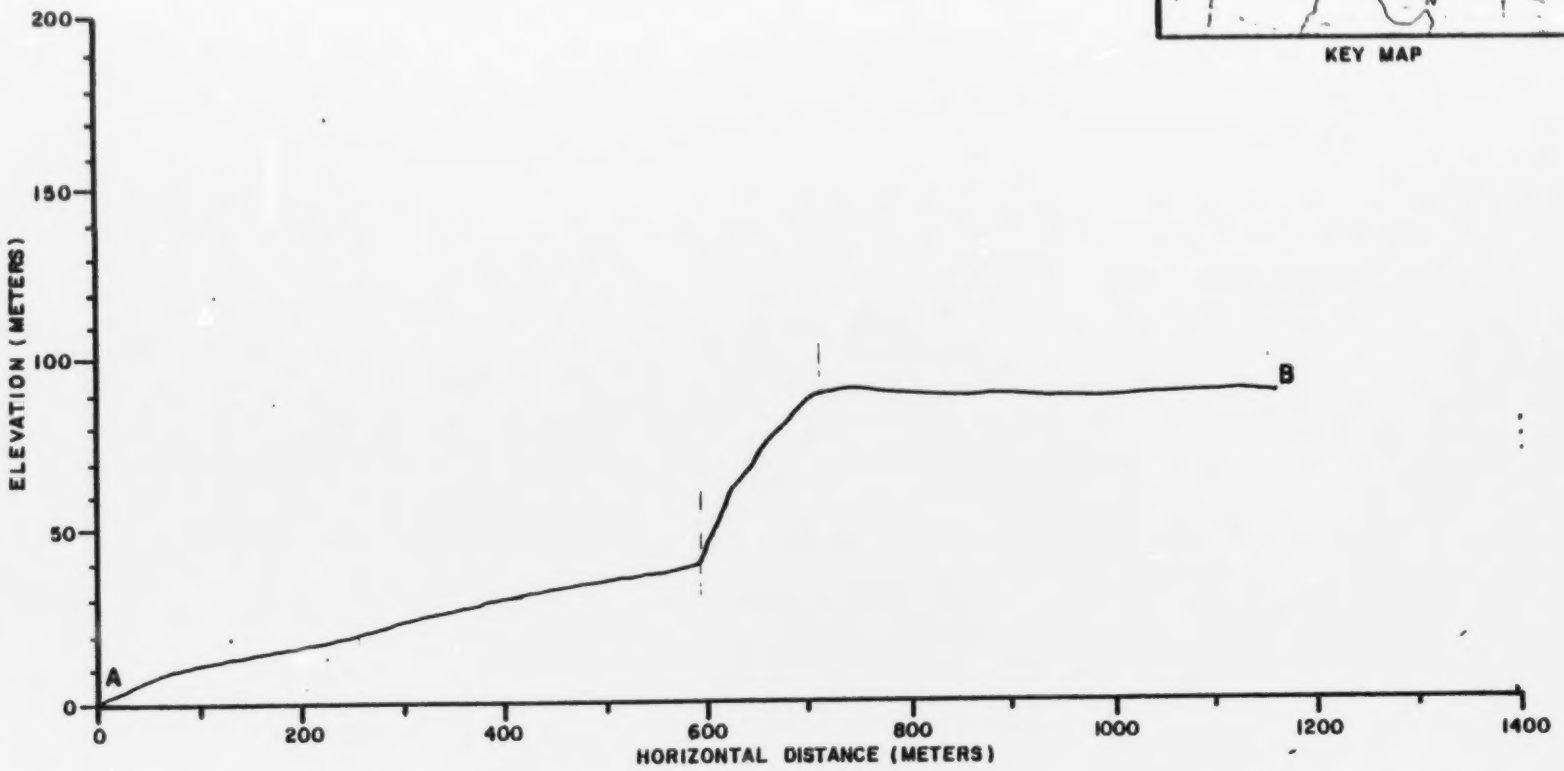


FIGURE 3.10

CROSS SECTION ANALYSIS

—BLACK TICKLE—



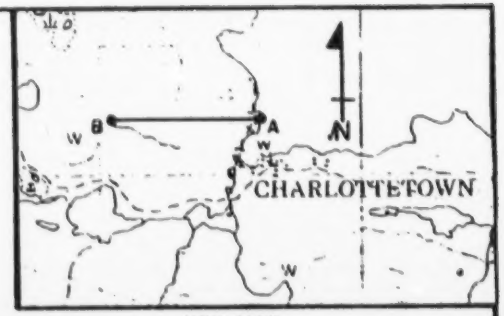
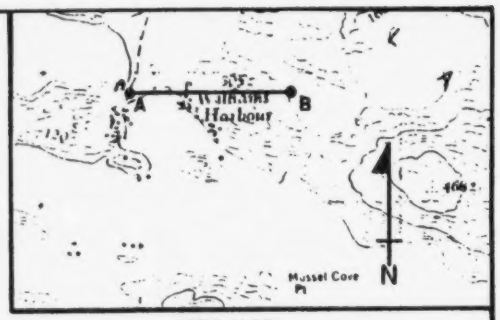


FIGURE 3.11
CROSS SECTION ANALYSIS
—CHARLOTTETOWN—



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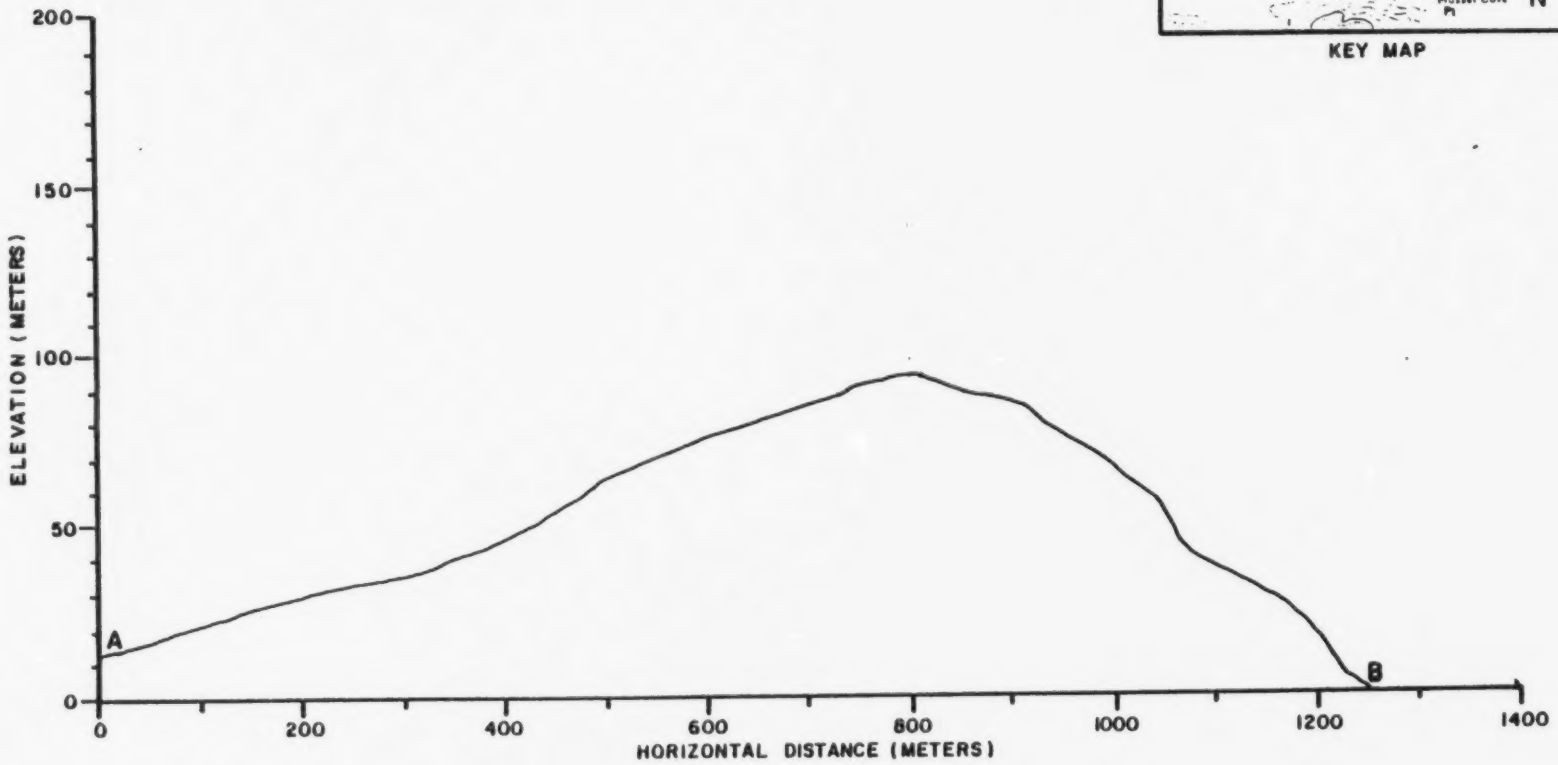
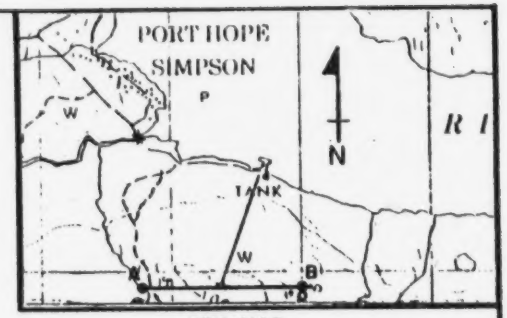


FIGURE 3.12
CROSS SECTION ANALYSIS
—WILLIAMS HARBOUR—



KEY MAP

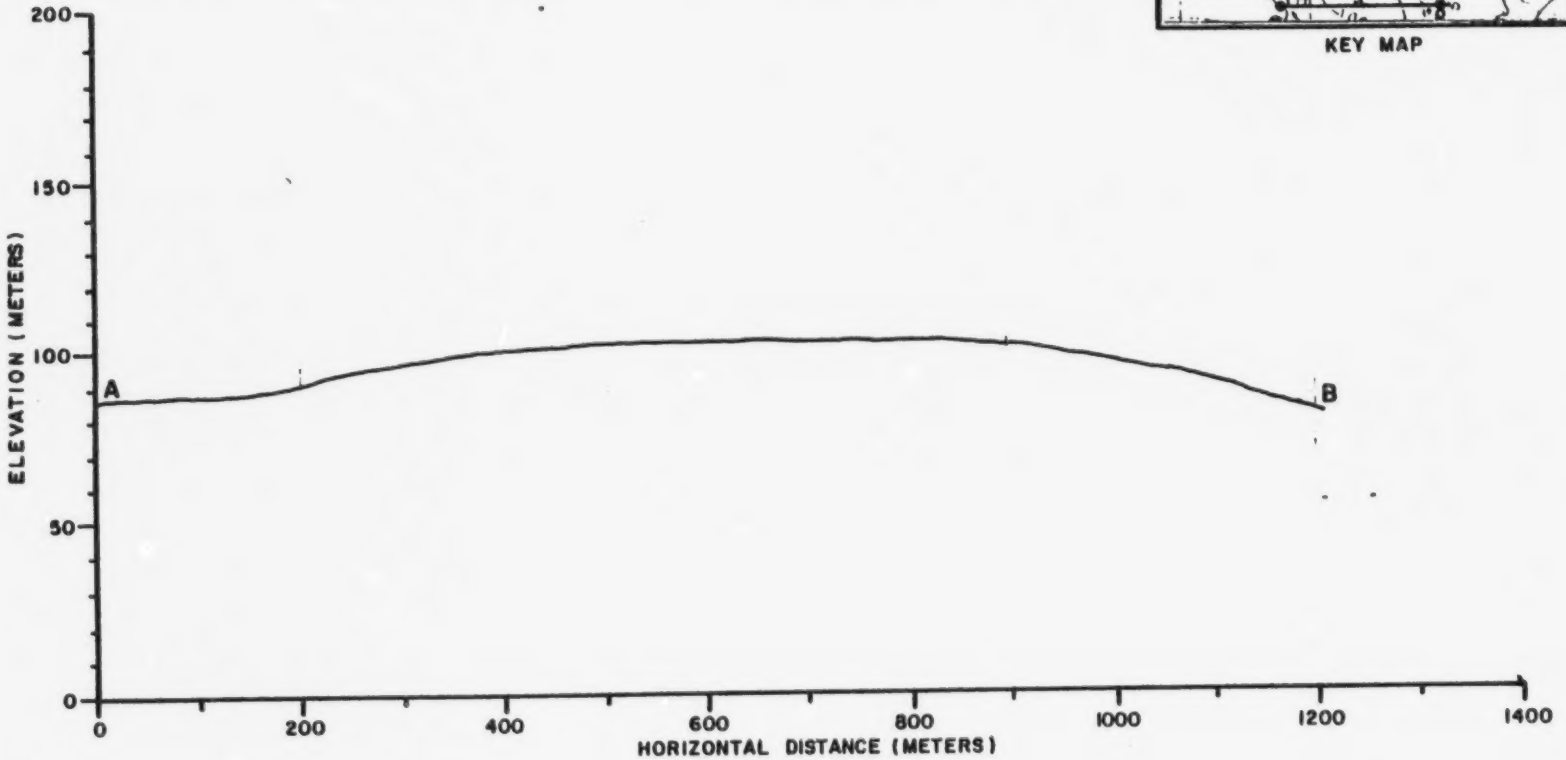
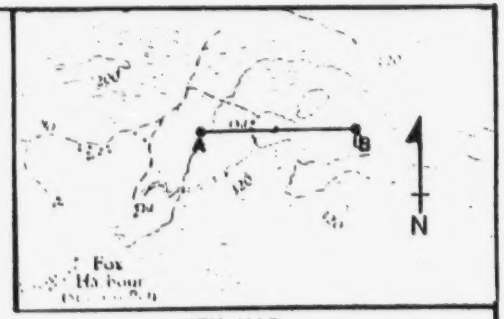


FIGURE 3.13

CROSS SECTION ANALYSIS

—PORT HOPE SIMPSON—



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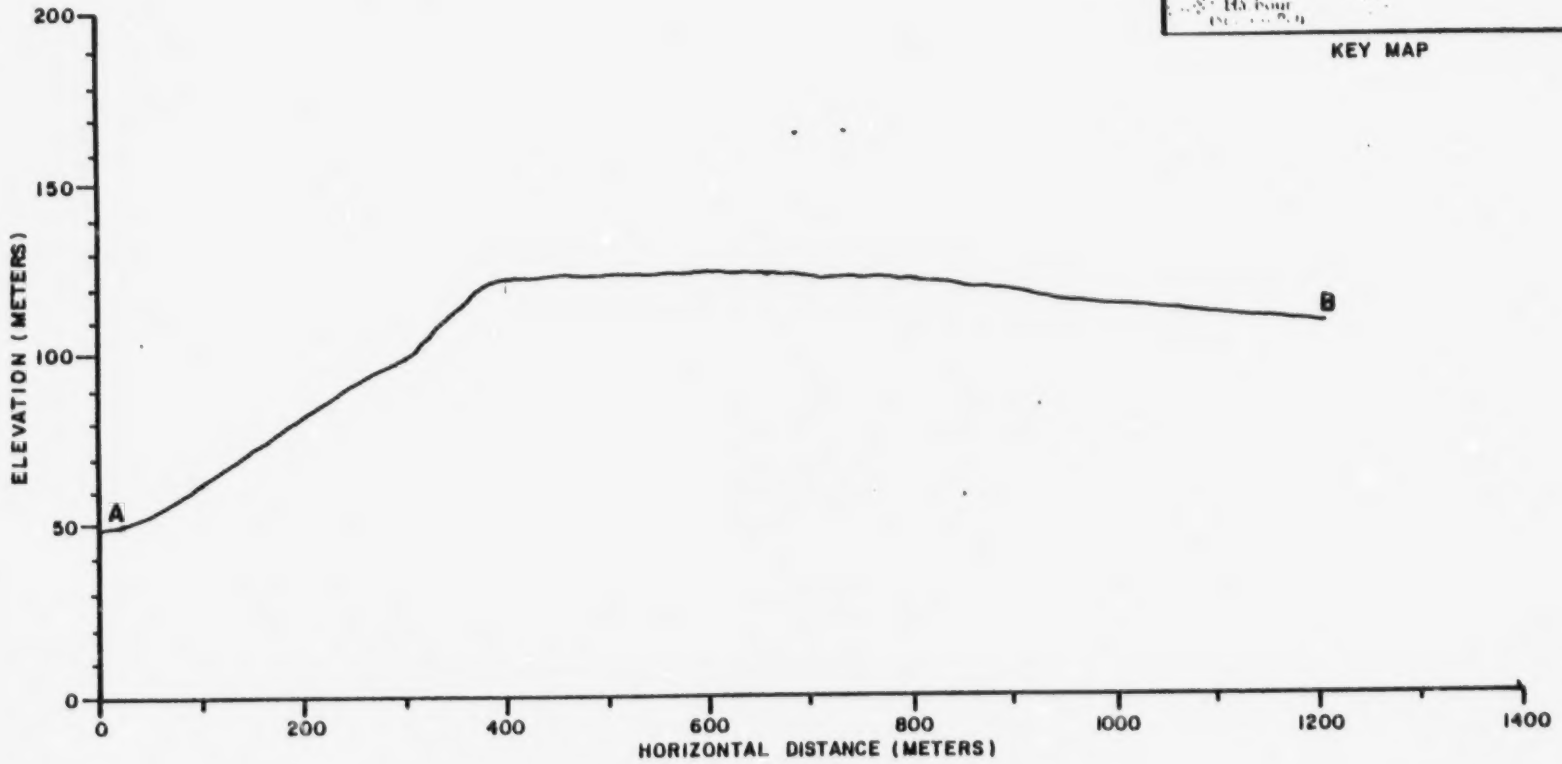
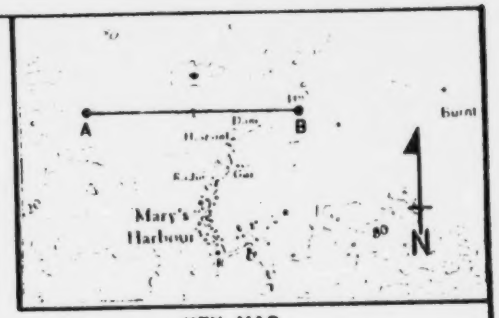


FIGURE 3.14

CROSS SECTION ANALYSIS
—ST. LEWIS—



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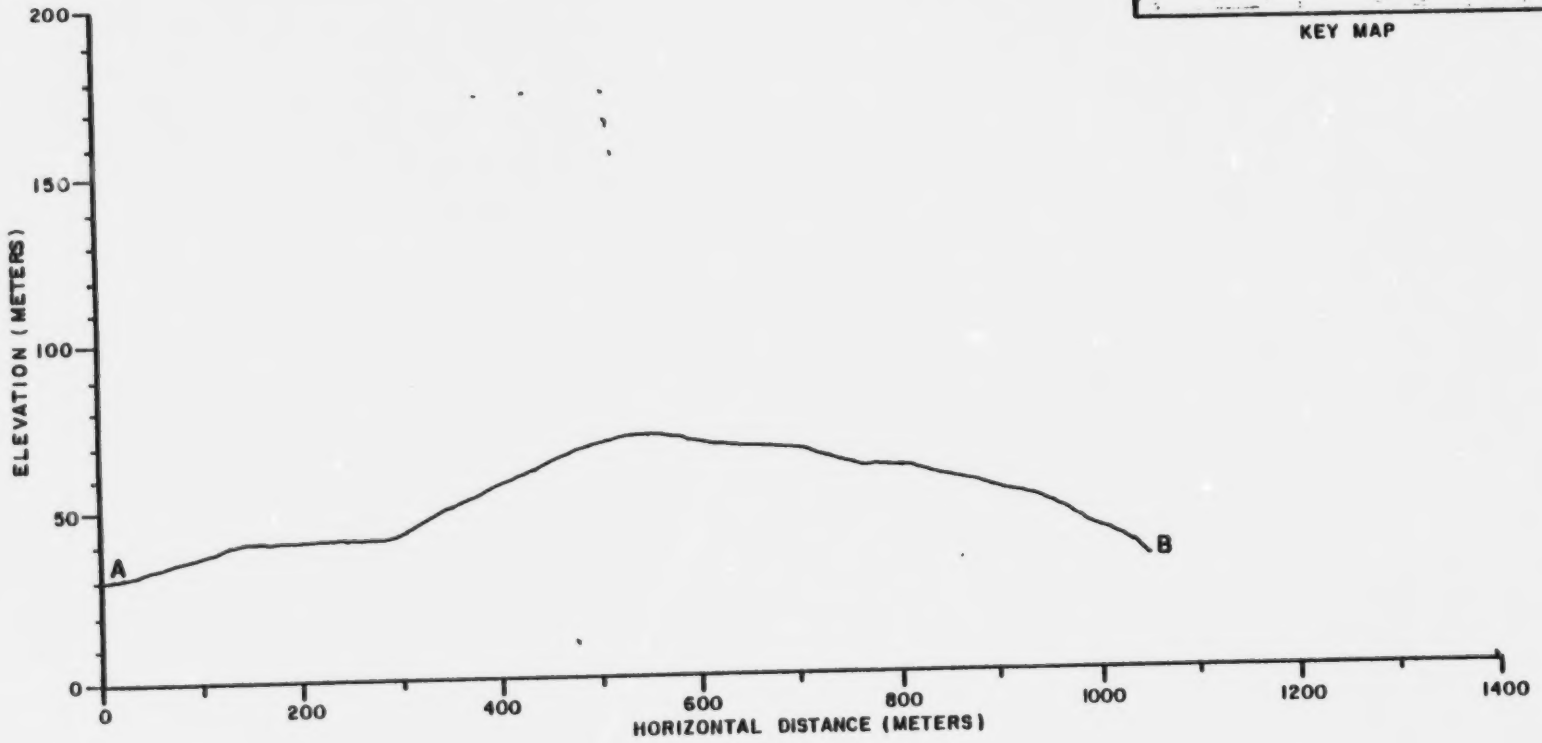
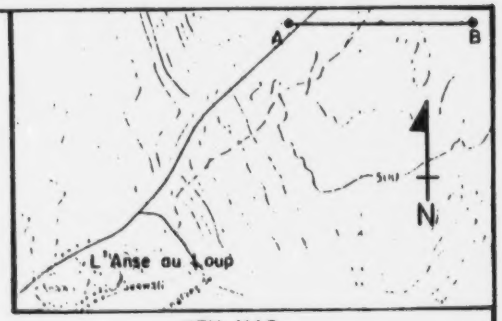


FIGURE 3.15

CROSS SECTION ANALYSIS

—MARY'S HARBOUR—



KEY MAP

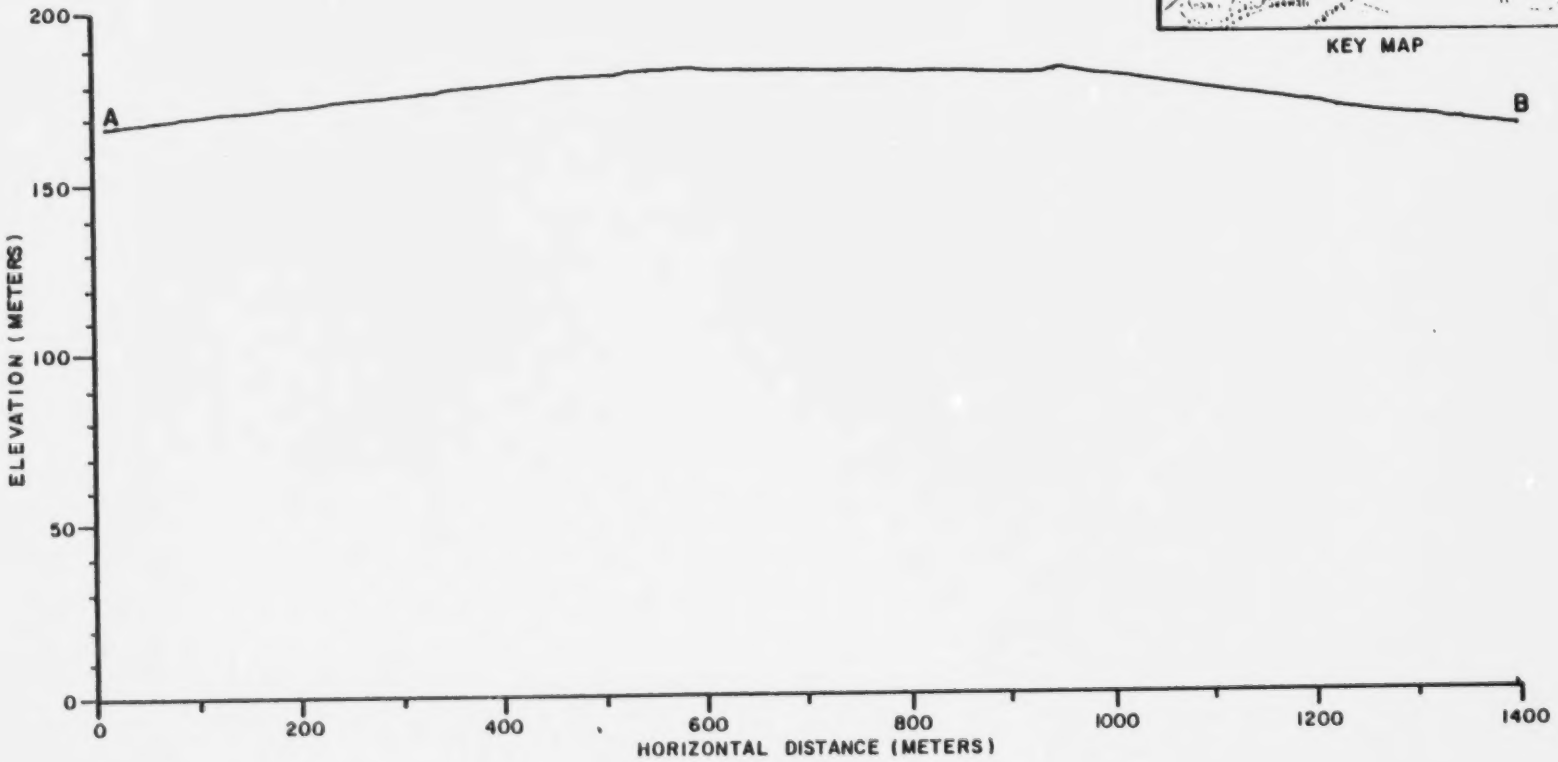


FIGURE 3.16

CROSS SECTION ANALYSIS
—L'ANSE AU LOUP—

PART FOUR

WECS

4.1 TECHNICAL REVIEW

4.1.1 General

The site assessment and evaluation exercise has identified six Labrador coastal communities as having potentially suitable sites for a wind energy conversion system.

In this section of the report, the characteristics of the electrical supply system of these communities are examined to establish the technical feasibility of integrating wind power into the system. Thereafter suitable wind turbines, selected from the list of WECS identified in the South Coast Wind Study, are matched with the community electrical system characteristics.

4.1.2 Technical Considerations

Operating a WECS in a large electrical grid system poses relatively few operational problems. The contribution from the wind turbine generator, because of its relatively small size, does not effect the quality of the power supplies or the system stability. This has proved to be the case with the large number of WECS installations operating satisfactorily in large grid systems.

However, integrating wind power into a small grid isolated system is not so straightforward, especially when high pentrations by wind power are necessary to save appreciable amounts of diesel fuel oil. The basic problem is one of matching the WECS output with both efficient operation of diesels, which must be kept running on line to meet load requirements, should the wind fail, and a changing system load.

Manufacturers generally recommend that diesel engines should not be operated at less than 40% rated output for extended periods of time. Otherwise, engine life and fuel efficiency are significantly reduced. This criterion limits the WECS output that a diesel generation system can accommodate to the difference between the system load and 40% of the on line diesel generation capacity.

A WECS may be selected on the basis that its maximum output is less than the difference between the system minimum load and efficient diesel generation. However, where economic considerations dictate that higher levels of penetration by wind power are required, larger WECS may be selected with special controls to either limit the wind turbine output or switch dummy loads at times when high wind conditions coincide with periods of low system loading.

4.1 TECHNICAL REVIEW (Cont'd)

4.1.2 Technical Considerations (Cont'd)

Both modes of operating have been considered in the selection of suitable WECS for each community. However, the analysis necessary to determine the economic feasibility of the installations is not within the scope of this report.

The maximum wind power penetration is, as expounded in the South Coast Wind Study, 60% of the system load. This level being contingent upon the ability of the diesel governors to respond to rapid changes in wind turbine output resulting from wind gusts, and efficient diesel operation. If on line diesel generation is maintained to meet the system load at all times, the 40% diesel generation condition will of course render the 60% penetration limit redundant. Only with detailed information on system load profiles and wind regimes at specific sites will it be possible to consider reducing on line diesel generation to less than that needed to meet the system load.

4.2 WECS SELECTION

A list of WECS suitable for operation in a marine environment is presented in Table 4.1. These machines were identified through the South Coast Wind Study on the basis of 46 weighted evaluation criteria. The evaluation criteria with weightings and evaluation forms completed by the WECS manufacturers of these machines are presented in Appendix C.

The final selection of suitable WECS for each of the sites simply consists of matching the power ratings of the listed models with the community diesel/WECS characteristics, as presented in Table 4.2, for both modes of operation and listing those selected for each site in order of total weighting.

4.2.1 Installation Without Special Controls

The WECS selected have maximum output ratings that are not significantly less than the maximum power, the respective diesel generation systems can accommodate during periods of system minimum load. It should be noted that the system minimum load at Makkovik is too low to support any of the identified WECS.

Nain

Maximum rating for WECS - 11 kW.

WECS Selected	Max. Power	Weighting
Enertech	5.3 kW	9280 pts

4.2 WECS SELECTION (Cont'd)

4.2.1 Installation Without Special Controls (Cont'd)

Paradise River

Maximum rating for WECS - 5 kW.

WECS Selected	Max. Power	Weighting
Enertech	5.3 kW	9280 pts

Cartwright

Maximum rating for WECS - 68 kW.

WECS Selected	Max. Power	Weighting
Enertech	44 kW	12375 pts
Moerup	65 kW	11091 pts
Daf-Indal	52 kW	11028 pts
Howden	60 kW	10925 pts

Saint Lewis

Maximum rating for WECS - 20 kW.

WECS Selected	Max. Power	Weighting
Northwind	16 kW	11016 pts
Windtech	20 kW	8137 pts

L'Anse An Loup

Maximum rating for WECS - 140 kW.

WECS Selected	Max. Power	Weighting
Windmaster	125 kW	10486 pts
Polymarin	100 kW	8834 pts
Adecon	125 kW	8175 pts

4.2.2 Installation Requiring Special Controls

In the event that economic analysis determine that a higher degree of penetration by wind power is necessary to render a WECS installation feasible, relatively large WECS installations will be required, with special control systems to ensure efficient diesel operation and quality of supplies.

Encouraging developments have been made by WECS manufacturers in this area by the use of microprocessor technology.

4.2 WECS SELECTION (Cont'd)

4.2.2 Installation Requiring Special Controls (Cont'd)

WECS have been selected which could, with the necessary controls, provide increased penetration. The optimum size of wind turbine for each site can only be determined by economic analyses.

Nain

Maximum rating for WECS - 224 kW.

WECS Selected	Max. Power	Weighting
Howden	200 kW	11147 pts
Windmaster	215 kW	10437 pts

Makkovik

Maximum rating for WECS - 148 kW.

WECS Selected	Max. Power	Weighting
Moreup	65 kW	11091 pts
Howden	100 kW	10925 pts
Windmaster	125 kW	10486 pts
Vesta	78 kW	10437 pts
Wintech	80 kW	9003 pts
Polymarin	100 kW	8839 pts
Adecon	125 kW	8175 pts

Paradise River

Maximum rating for WECS - 41 kW.

WECS Selected	Max. Power	Weighting
Enertech	27 kW	11413 pts
Man	33 kW	10490 pts
Wintech	20 kW	8137 pts
Extrawatt	30 kW	6095 pts

Cartwright

Maximum rating for WECS - 272 kW.

WECS Selected	Max. Power	Weighting
Howden	200 kW	11147 pts
Windmaster	215 kW	10437 pts

4.2 WECS SELECTION (Cont'd)

4.2.2 Installation Requiring Special Controls (Cont'd)

Saint Lewis

Maximum rating for WECS - 143 kW.

WECS Selected	Max. Power	Weighting
Moerup	65 kW	11091 pts
Howden	100 kW	10925 pts
Windmaster	125 kW	10486 pts
Vesta	78 kW	10437 pts
Wintech	80 kW	9003 pts
Polymarin	100 kW	8839 pts
Adecon	125 kW	8175 pts

L'Anse Au Loup

Maximum rating for WECS - 968 kW.

WECS Selected	Max. Power	Weighting
Howden	333 kW	10925 pts
Carter	280 kW	10887 pts
Daf-Indal	522 kW	10198 pts
FDO Stork	300 kW	8489 pts

TABLE 4.1

SUMMARY OF WEIGHTING FOR SUITABLE WECS

Manufacturer	Model	Type	Rating	Weighting Points
Carter Wind System	25	HAWT	25 kW	12965
	250	HAWT	250 kW	10887
Enertech Corp.	44/40	HAWT	40 kW	12375
	44/25	HAWT	25 kW	11413
	21/5	HAWT	5 kW	9280
Wind Tech. Inc.	120	HAWT	20 kW	8137
	180	HAWT	80 kW	9003
DAF-INDAL	1300	VAWT	50 kW	11028
	6400	VAWT	522 kW	10198
M.A.N.-GHH (Canada) Inc.	Aeroman 12.5/33	HAWT	33 kW	10490
North Wind Power Co.	L-916	HAWT	16 kW	11016
Adecon Energy Systems Inc.	125	VAWT	125 kW	8175
F.D.O. Windenergie System	NEWGCS -25	HAWT	300 kW	8489
Moerup Industrial Windmills	60/17	HAWT	65 kW	11091
Howden Group Canada Ltd.	HWP 60	HAWT	60 kW	10925
	HWP 200	HAWT	200 kW	11147
	HWP 330	HAWT	330 kW	10925
Polymarin B.V.	Pionier 1	VAWT	100 kW	8839
MH2 Windmaster	100/22	HAWT	100 kW	10486
	150/22	HAWT	150 kW	10560
	200/22	HAWT	200 kW	10436
Vesta Energy	V-15	HAWT	65 kW	10437
Extrawatt Inc.	Ex-30	HAWT	30 kW	6095

TABLE 4.2

COMMUNITY DIESEL/WECS CHARACTERISTICS

Community	Diesel Plant No. x Size (kW)	System Min. Load (kW)	System Peak Load (kW)	Maximum WECS Contribution	
				Uncontrolled System (kW)	Controlled System (kW)
Nain	3 x 300 1 x 350	131	464	11	224
Makkovik	2 x 250 1 x 450	103	328	3	148
Paradise River	2 x 40 1 x 60	21	73	5	41
Cartwright	2 x 300 1 x 250	168	492	68	272
St. Lewis	2 x 136 1 x 220 1 x 75	50	261	20	143
L'Anse au Loup	1 x 1100 1 x 800 2 x 600	380	1728	140	968

PART FIVE

CONCLUSIONS AND RECOMMENDATIONS

5.0 CONCLUSIONS AND RECOMMENDATIONS

5.1 SITE ASSESSMENT METHODOLOGY

The site assessment methodology, as decribed in Section 2.3 of this report, is considered to provided an adaquate evaluation as to whether a site has the potential to support a WECS. This was proven by a study previously carried out on the south coast of Newfoundland and this report will serve as reinforcement to the fact that the methodology does work.

Subjective evaluation, however, forms a part of completing the site assessment in an accurate and fair manner. Provided good judgement is applied to the subjective evaluation required to complete the site assessments, this type of study will always result in the selection of the best possible WECS sites from the candidates being considered.

5.2 RESULTS OF SITE ASSESSMENT METHODOLOGY

Based on the results of the site assessment portion of this study the following communities are considered to have the highest potential for supporting a WECS.

Cartwright	115
L'Anse au Loup	115
Makkovik	105
Saint Lewis	105
Nain	85
Paradise River	85

5.3 VERIFICATION OF SELECTED SITES

In order to verify that the selected sites are suitable for a WECS installation it is recommended that a visit be arranged to the six communities identified as having the highest potential. This type of visit would be particularly useful in the case of L'Anse au Loup as the power grid available for connection of a WECS extends from L'Anse au Loup to Red Bay. Field reconnaissance of this area will possibly turn up a more suitable site than the one identified during the desk study. Generally a site visit will confirm that the selected sites are, in fact, suitable or constraints to the development of the site will be revealed.

5.4 WECS SELECTION

It is concluded that for each of the six Labrador communities identified as having a potential wind site, the diesel generator supply system can technically support wind power integration, with special control arrangements of WECS output and/or load demand. Only at Makkovik is the system minimum load too low to support a WECS without special controls.

5.4 WECS SELECTION (Cont'd)

Suitable wind turbines have been selected for each site, from the machines identified in the South Coast Wind Study, solely on the basis of technical considerations. It will be necessary to study the economic feasibility of installing the preliminary selected WECS at the identified sites before a final selection can be made.

APPENDIX A

SAMPLE QUESTIONNAIRE

FOR

SITE SELECTION SURVEY

SAMPLE QUESTIONNAIRE FOR SITE SELECTION SURVEY

Please Answer All Questions

NAME: _____

ADDRESS: _____

_____

TELEPHONE NO. _____

OCCUPATION: _____

PART I - WEATHER INFORMATION

1. (a) From what direction are the prevailing winds in your community during summer? (Circle One)

   North South East West

   (b) From what direction are the prevailing winds in your community during winter? (Circle One)

   North South East West

2. Would you say it is windy enough in your community to blow dust and loose paper around? (Circle One)

   (a) most every day

   (b) 2 - 3 times a week

   (c) once a week

   (d) less than once per week

   (e) less than once per month

3. Approximately how hard does the wind blow during the worst storms of the year? (Circle One)

   (a) 30 - 35 miles/hour

   (b) 35 - 40 miles/hour

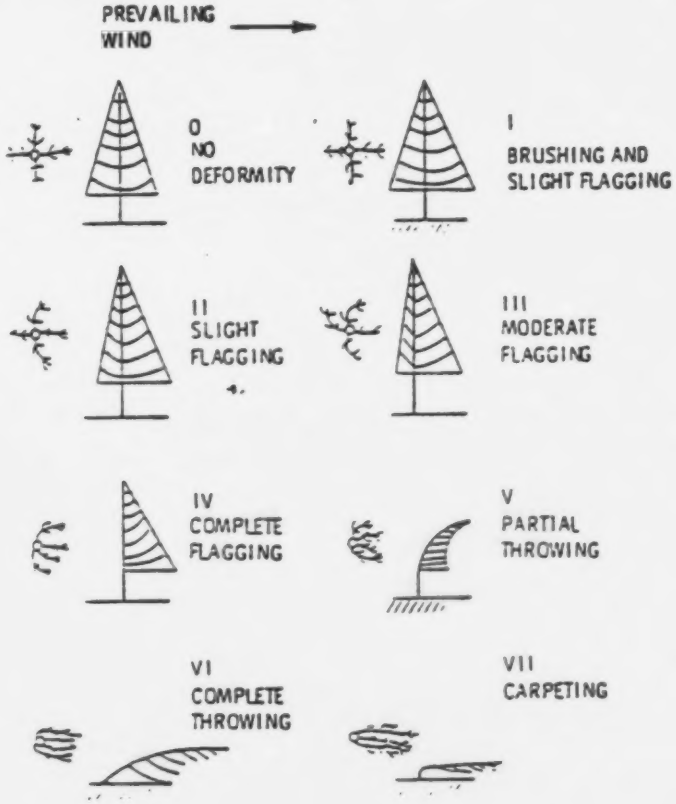
   (c) 40 - 45 miles/hour

   (d) greater than 45 miles/hour

SAMPLE QUESTIONNAIRE (Cont'd)

4. If there are any trees or shrubs around your community, which of the following illustrations best describes the long term effects of the winds on the local vegetation? (Circle One)

(If there is no vegetation near your community, go to Question No. 5.)



5. (a) Does your community have many periods of freezing rain (silverthaw) or freezing drizzle during the year?

YES _____ NO _____

(b) Approximately how many periods of freezing rain (silverthaw) or drizzle does your community have each year?

_____

(c) During what months does freezing rain (silverthaw) or drizzle occur? (Circle Appropriate Months)

January February March April May June

July August September October November December

SAMPLE QUESTIONNAIRE (Cont'd)

PART I - WEATHER INFORMATION (Cont'd)

6. When freezing rain occurs, is there a large accumulation of ice on wires and trees, etc. [i.e. more than one centimetre (1/2 inch)]?

YES _____ NO _____ No Freezing Rain _____

7. (a) What is the thickest ice accumulation you have seen from freezing rain or drizzle?

APPROXIMATELY _____ inches

(b) Approximately when did the ice accumulation mentioned in Question 7(a) take place?

MONTH _____ YEAR _____

8. Does your community have many thunder storms? (Circle One)

(a) 1 per year

(b) 2 -3 per year

(c) more than 3 per year

PART II - TOPOGRAPHY

9. If you were putting up a wind mill in your community, where would you put it? Please describe the location or sketch the location on the back of this sheet.

10. (a) Are any of these locations, mentioned in Question 9, within 750 feet of existing power lines?

YES _____ NO _____ HOW CLOSE? _____ feet

(b) Are any of these locations within 600 feet of houses?

YES _____ NO _____ HOW CLOSE? _____ feet

(c) Are any of these locations within 300 feet of the diesel plant

YES _____ NO _____ HOW CLOSE? _____ feet

SAMPLE QUESTIONNAIRE (Cont'd)

PART II - TOPOGRAPHY (Cont'd)

11. Are the areas mentioned in Question 8 accessible by any of the following means:

(a) Foot? YES _____ NO _____

(b) Truck? YES _____ NO _____

(c) Boat? YES _____ NO _____

(d) All Terrain Vehicle? YES _____ NO _____

PART III - COMMUNITY IMPACT

12. Do you feel that your community would benefit from the placement of a wind powered electrical generating system?

YES _____ NO _____

IF YES, WHAT DO YOU THINK THE BENEFITS WOULD BE?

_____

_____

IF NO, WHAT DISADVANTAGES DO YOU FORSEE?

_____

_____

13. Is any construction equipment, i.e. backhoes or cranes, available for hire in the town?

YES _____ NO _____

IF YES, WHO OWNS THE EQUIPMENT? _____

_____

SAMPLE QUESTIONNAIRE (Cont'd)

PART III - COMMUNITY IMPACT (Cont'd)

14. Do you have any objections to the installation of a wind energy system in your area?

YES _____ NO _____

IF YES, PLEASE EXPLAIN.

_____

_____

_____

_____

_____

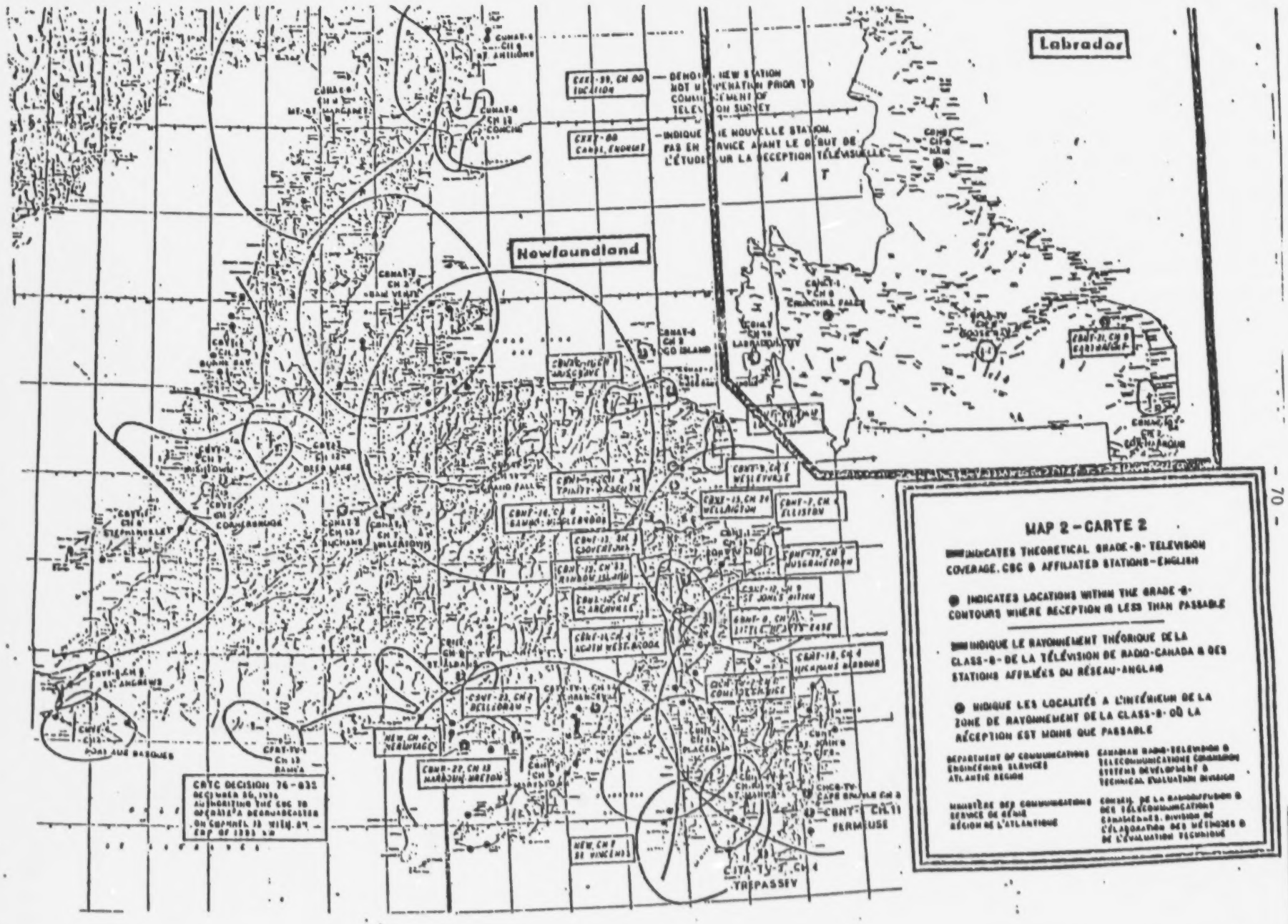
15. If you have any additional comments, please feel free to use the reverse side of the sheet. All comments are welcome.

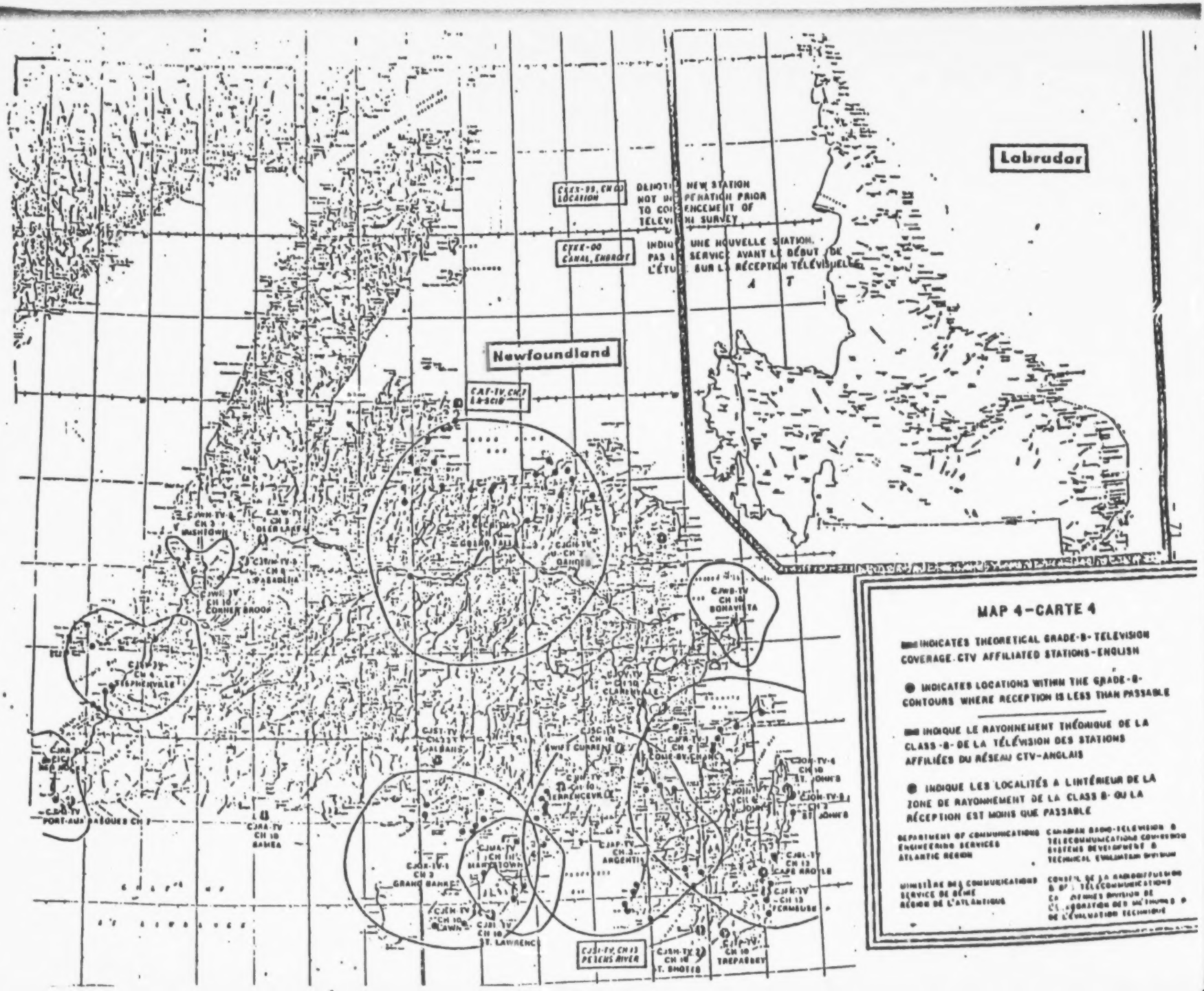
THANK YOU FOR YOUR COOPERATION.

APPENDIX B

TELEVISION SIGNAL COVERAGE

NEWFOUNDLAND


Labrador
Newfoundland
MAP 2 – CARTE 2
INDICATES THEORETICAL GRADE-B TELEVISION COVERAGE. CBC & AFFILIATED STATIONS – ENGLISH
INDICATES LOCATIONS WITHIN THE GRADE-B CONTOURS WHERE RECEPTION IS LESS THAN PASSABLE
INDIQUE LE RAYONNEMENT THÉORIQUE DE LA CLASS-B DE LA TÉLÉVISION DE RADIO-CANADA & DES STATIONS AFFILIÉES DU RÉSEAU-ANGLAIS
INDIQUE LES LOCALITÉS À L'INTÉRIEUR DE LA ZONE DE RAYONNEMENT DE LA CLASS-B OÙ LA RÉCEPTION EST MOINS QUE PASSABLE
DEPARTMENT OF COMMUNICATIONS
ENGINEERING SERVICES
ATLANTIC REGION
CANADIAN RADIO-TELEVISION & TELECOMMUNICATIONS COMMISSION
SYSTEMS DEVELOPMENT & TECHNICAL EVALUATION DIVISION
MINISTÈRE DES COMMUNICATIONS
SERVICE DE GÉNIE
RÉGION DE L'ATLANTIQUE
CONSEIL DE LA RADIODIFFUSION & DES TÉLÉCOMMUNICATIONS CANADIENNES, DIVISION DE L'ÉLABORATION DES MÉTHODES & DE L'ÉVALUATION TECHNIQUE
CBTC DECISION 76-832
DECEMBER 16, 1976
AUTHORIZING THE CBC TO OPERATE A REBROADCASTER ON CHANNEL 13 WITH 89 – ERP OF 1285 kW
CBNT – CH 11
FERMEUSE
CITA-TV-2, CH 4
TREPASSEY


Labrador
Newfoundland
MAP 4 – CARTE 4
INDICATES THEORETICAL GRADE-B- TELEVISION COVERAGE. CTV AFFILIATED STATIONS-ENGLISH
INDICATES LOCATIONS WITHIN THE GRADE-B- CONTOURS WHERE RECEPTION IS LESS THAN PASSABLE
INDIQUE LE RAYONNEMENT THÉORIQUE DE LA CLASS-B- DE LA TÉLÉVISION DES STATIONS AFFILIÉES DU RÉSEAU CTV-ANGLAIS
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SERVICE DE GÉNIE
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CONSEIL DE LA RADIODIFFUSION ET DES TÉLÉCOMMUNICATIONS CANADIENNES
DIVISION DE L'ÉLABORATION DES NORMES ET DE L'ÉVALUATION TECHNIQUE

APPENDIX C

WECS EVALUATION CRITERIA DESCRIPTIONS AND WEIGHTINGS

AND

EVALUATION/SELECTION FORMS

EVALUATION CRITERIA DESCRIPTION AND WEIGHTINGS

1. Annual Energy Output (AEO) with Annual Average Wind Speed of 23 kph (14 mph) at 10 m above ground level.

   Description: Determined using Rayleigh wind speed distribution for annual average wind speed at hub or equator height, and assuming 100% availability.

   Example: 37,000 kWh at hub height

   Weighting: No Score

2. Design Minimum Life.

   Description: Minimum number of years total system is designed to function normally (assuming all operation and maintenance requirements are adhered to) in a harsh onshore marine environment.

   Example: 25 years

   Weighting:

Design min. life of:	
30 years and more	125
25 years to 29 years	100
20 years to 24 years	75
Less than 20 years	0

3. Maximum Power

   Description: The highest power level given on the power curve. State corresponding wind speed.

EVALUATION CRITERIA DESCRIPTION AND WEIGHTINGS (Cont'd)

.3 Maximum Power (Cont'd)

Example: 30.5 kW @15 m/s (34 mph)

Weighting: No Score

4. Power Curve

Description: Brief description of method used to plot Power Curve. State if in compliance with AWEA, IEA, CSA or other agency.

Example: Based on field tests to AWEA, 1982

Weighting:

If determined using the method of BINS (AWEA, IEA, CSA, etc.)	300
Determined by calculation only	0

5. Turbine Tower Features

Description: Include general design (lattice, tubular, etc.), whether guyed or free standing, tower material and finish, access means to nacelle (internal or external ladder, elevator, etc.)

Example: Tubular, steel, self-supporting, inside ladder, hot galvanized.

Weighting:

Tubular, Self Supporting Internal ladder (or elevator)	100
Tubular, Self Supporting, External ladder (or elevator).	75
Tubular, Guyed, Internal ladder (or elevator).	70
Tubular, Guyed, External ladder (or elevator).	65
Lattice, Self Supporting ladder (or elevator).	60
Lattice, guyed ladder (or elevator).	50
(Subtract 50 pts for inadequate finish)	

6. Standard Height at Hub or Equator

Example: 20 m (65.6 ft)

Weighting: No Score

EVALUATION CRITERIA DESCRIPTION AND WEIGHTINGS (Cont'd)

7. Height Options

Example: 30 m (98.4 ft)

Weighting:		
	3 or more options	60
	1 or 2 options	50
	No options	0

8. Blade Materials

Example: Laminar wood spare with fiber glass and expoxy

Weighting:	Used as a TV/EMI Indicator:	
	Little or no metal used	50
	Primary materials are metallic	0

9. Electrical System

Example: Induction generator 20 kW, 480 VAC, 3 phse, 60 Hz, 1800 rpm.

Weighting: No Score

10. Ambient Operating Temperature

Description: Design range of ambient temperatures the WECS will function normally in.

Example: -30° C to 40° C (-22° F to 104° F)

Weighting:	Design Minimum ambient temp:	
	-25°C (-13°F) and below	100
	-24°C (-11°F) to -20°C (-4°F)	75
	-19°C (-2°F) to -15°C ($+5^{\circ}$F)	50
	-14°C (7°F) to -10°C ($+14^{\circ}$F)	25
	Higher than -9°C ($+16^{\circ}$F)	0

11. Starting Arrangement

Description: Method used to start unit. Provide starting current at cut in wind speed.

Example: Wye-Delta Starter, 120 A maximum.

Weighting: No Score

12. Maximum Design Wind Speed

Description: Maximum wind speed the WECS, in automatic unattended operation (not necessarily generating), is designed to sustain without loss of ability to function normally.

EVALUATION CRITERIA DESCRIPTION AND WEIGHTINGS (Cont'd)

12. Maximum Design Wind Speed (Cont'd)

Example: 50 m/s (110 mph)

Weighting:		
	> 55 m/s (121 mph)	200
	45 m/s (99 mph) to 55 m/s (119 mph)	150
	39 m/s (86 mph) to 44 m/s (97 mph)	50
	< 39 m/s (86 mph)	0

13. Maximum Tested Wind Speed

Description: Maximum wind speed the WECS, in automatic unattended operation (not necessarily generating), has actually sustained without loss of ability to function normally.

Example: 40 m/s (88 mph)

Weighting:		
	> 55 m/s (121 mph)	200
	45 m/s (99 mph) to 55 m/s (119 mph)	150
	39 m/s (86 mph) to 44 m/s (97 mph)	50
	< 39 m/s (86 mph)	0

14. Failures Due to High Wind

Description: The number of machine malfunctions, this model thus far experienced, that can be directly or indirectly attributed to high wind speeds. State wind speed resulting in failure.

Example: 3

Weighting: No Failures: 3 x max. tested wind speed (mph).
1 to 5 failures: 2 x max. tested wind speed (mph).
6 or more failures: 0 points

15. Overspeed Control

Description: Methods used to prevent excess rotational speeds. State if manual or automatic reset.

Example: Blade feathering, mechanical brake, both automatically reset.

EVALUATION CRITERIA DESCRIPTION AND WEIGHTINGS (Cont'd)

15. Overspeed Control (Cont'd)

Weighting:

Mechanical Brake capable of stopping turbine at all wind speeds and Aerodynamic Brake, Automatically activated by overspeed, effective at all wind speeds	300
Aerodynamic Brake only	100
Mechanical Brake only	50

16. Maximum Ice Load

Description: Design maximum radial ice thickness of WECS system, while parked, without incurring damage .

Example: 40 mm in 80 km wind

Weighting: Designed to radial ice thickness:

90 mm (or 50 mm at 80 km wind)	300
75 mm (or 40 mm at 80 km wind)	200
44 mm (or 25 mm at 80 km wind)	100
Less than 44 mm	0

17. Ice Detection

Description: Are means employed to cause automatic shut down of the WECS during icing conditions? State if manual or automatic reset.

Example: Ice detection standard, manual reset.

Weighting: No Score. (A "No" may result in disqualification).

18. Ice Detection Experience

Description: Number of occasions this model has been exposed to icing conditions. Number of failures resulting directly or indirectly from these icing conditions.

Example: 100 exposures, 0 failure

Weighting: Score determined by dividing no. of exposures to icing conditions by (n + 1) where n = no. of failures due to ice. i.e., 100 exposures and 0 failure: 100/(0+1) = 100

EVALUATION CRITERIA DESCRIPTION AND WEIGHTINGS (Cont'd)

19. Noise Level

Description: Noise level measured at 150 m downwind from operating turbine.

Example: 40 db

Weighting:

≤ 50 db	300
> 50 db	0

20. Vibration Protection

Description: Are means provided to cause automatic turbine shutdown due to excessive vibration? State if manual or automatic reset.

Example: Yes, Auto Reset

Weighting: No Score. (A "No" will probably result in disqualification).

21. Proximity to Dwellings

Description: Manufactuerer's recommended minimum distance between turbine and nearest dwelling, road, etc. (shedding of turbine components and ice should be considered)

Example: 250 m (820 ft)

Weighting: No Score (information to be used as design reference).

22. Manually Operated Brake

Description: Can this machine be stopped, by manually operating a brake, under any circumstances? If yes briefly describe.

Example: Yes, override switch located at tower base.

Weighting:

Yes	500
No	0

23. Lightning Protection

Description: Are the electrical and mechanical systems protected from lightning strikes?

Example: Yes

EVALUATION CRITERIA DESCRIPTION AND WEIGHTINGS (Cont'd)

23. Lightning Protection (Cont'd)

Weighting:	Yes	500
	No	0

24. Skills of O & M Personnel

Description: Does a typical diesel mechanical/operator have the necessary skills to provide routine O & M of WECS assuming initial training is given?

Example: Yes

Weighting: Does diesel mechanic have necessary skills?

Yes	300
No	0

25. Service and Maintenance Equipment

Description: List heavy or special equipment needed for routine service and maintenance.

Example: 1-30 ton crane with 100 ft. boom.

Weighting:

No special heavy equipment required.	800
Yes	0

26. Machine Evaluation

Description: Has this machine model been evaluated by an independent wind turbine test facility such as: Rocky Flats, AWTS, RISOE or ECN? If "Yes", give name of facility and year test was made. What downtime due to problems if any during testing and why?

Example: Yes, RISOE . . . 1980.

Weighting:

Yes (no downtime due to problems in 5 months testing)	3000
Yes (Down less than 5% due to minor problems)	2000
Yes (Down 5% - 10% due to minor problems)	1000
Yes (Down > 10% due to problems)	0
No	0

EVALUATION CRITERIA DESCRIPTION AND WEIGHTINGS (Cont'd)

27. Safety/Security Features

Description: List additional security/safety features offered in standard package.

Example: Overtemperature indications, undervoltage protection

Weighting: No Score

28. Availability Guaranty

Description: Is an availability guaranty/warranty offered as standard? If "Yes" outline benefits.

Example: No

Weighting:		
	Yes	500
	No	0

29. Power Production Guaranty

Description: Is a power production guaranty/warranty offered as standard? If yes briefly out-
line primary benefits.

Example: No

Weighting:		
	Yes	500
	No	0

30. Maximum Design Wind Speed Guaranty

Description: Is a maximum design wind speed guaranty/warranty offered as standard? If "yes", briefly outline primary benefits.

Example: Yes . . . contingent on satisfactory wind data availability.

Weighting:		
	Yes	500
	No	0

31. General Guaranty

Description: Brief outline of guaranty on each major system component.

Example: All products have standard one-year parts and labour warranty.

EVALUATION CRITERIA DESCRIPTION AND WEIGHTINGS (Cont'd)

31. General Guaranty (Cont'd)

Weighting: Score determined by multiplying no. of years guaranteed by 200.

32. Total System Weight

Description: Total system weight including tower. Give tower size(s)

Example: 9500 kg (20,943 lbs), 20 m (66 ft.)

Weighting: No Score

33. Weight of Heaviest Component

Description: Weight and identity of heaviest system component (including tower components) when prepared for shipment.

Example: 2550 kg (5622 lbs). Nacelle

Weighting: No Score

34. Length of Longest Component

Description: Dimensions and Weight of longest system component (including tower components) when prepared for shipment. Identify component and give tower size if applic-
able.

Example: 12 m x 1 m x .25 m, 1050 kg (39 ft. x 3.3 ft. x .8 ft.), (2315 lbs) Tower Section, 20 m Tower.

Weighting: No Score

35. Erection and Installation Equipment

Description: Essential equipment needed on site to erect/install WECS

Example: 1-30 ton crane with 100 ft. boom 1-backhoe, 1-electric welding machine.

Weighting: No special heavy equipment as per example requred. 800
Delete 200 points for each item of special heavy equipment required.

EVALUATION CRITERIA DESCRIPTION AND WEIGHTINGS (Cont'd)

36. Erection and Installation Assistance

Description: Are expert installers normally provided by manufacturer? State additional cost if applicable.

Example: Yes, no additional costs

Weighting:		
	Yes, no additional cost.	100
	Experts not required.	100
	Yes, additional cost.	25

37. Number of Machines in Operation

Description: Number of machines (this model) installed and operating as per specifications.

Example: 85

Weighting: Three points per machine of proposed model up to a maximum of 1500 pts.

38. Number of Years Model in Production

Description: State number of years this model has been produced.

Example: 4 years.

Weighting: Score determined by Multiplying no. of years in production by factor of 50

39. Delivery Time

Description: Approximate delivery time after receipt of order.

Example: 6 months

Weighting:		
	6 months and less	100
	> 6 months	0

40. Wind-Diesel Experience

Description: Number of machines that have been electrically intertied with diesel generating plants. Give the percentage of penetration of the wind turbine into any such system based on minimum system load, and outline the controls, if any, used to maintain optimum penetration levels.

EVALUATION CRITERIA DESCRIPTION AND WEIGHTINGS (Cont'd)

40. Wind-Diesel Experience (Cont'd)

Example: 2 machines 15% of minimum system load. Microprocessor based control of blade pitch.

Weighting: Score determined by multiplying "Number of W-D Systems" by "Percentage of penetration". Resulting product increased by factor of 10 to 50 based on efficacy of penetration level controls.

Example: 3 systems, 15% penetration
Score: 3 x 15 x 50 = 2250 pts.

41. Availability

Description: Average availability of installed machines and primary reason for downtime.

Example: 85%, downtime due primarily to maintenance

Weighting: No Score

42. Turbine Cost

Description: Total cost of WECS (Standard package) including tower, generator, and control system. Give tower size(s) if applicable.

Example: C$55,000

Weighting: No Score

43. Erection and Installation Costs

Description: Average historical erection and installation costs, including foundation and guy anchors, but not including access roads.

Example: C$20,000

Weighting: No Score

44. Operation and Maintenance Costs

Description: Estimate of annual operation and maintenance costs. Confirmed by actual O & M report if possible.

Example: 2% of total installed cost

EVALUATION CRITERIA DESCRIPTION AND WEIGHTINGS (Cont'd)

44. Operation and Maintenance Costs (Cont'd)

Weighting:	No O&M Report
	0
2% and less	200
> 2%	0

45. Total Cost

Description: Sum of WECS cost and erection and installation cost.

Example: C$75,000.

Weighting: No Score

46. Cost of Energy

Description: Raw installation energy cost. Determined by dividing total cost by AEO for a given annual average wind speed.

Example: Total cost C$75,000, AEO 37,000 kWh (see item 1).
Cost of energy = C$75,000/37,000 kWh
C$2.02 kWh

Weighting: Raw cost of energy C$/kWh	
$1.00 and less	2000
$1.01 to $2.00	1000
$2.01 to $3.00	500
$3.01 to $4.00	250
$4.01 and over	100

WIND ENERGY CONVERSION SYSTEM

EVALUATION FORMS

WECS SUMMARY SHEET

MANUFACTURER:
ADDRESS:
CONTACT PERSON:
TELEPHONE NO.:
TELEX:

TURBINE MODEL:
TYPE (VAWT, HAWT):
TURBINE DIMENSIONS:
SWEPT (CAPTURE) AREA:
NUMBER OF BLADES:
CUT-IN WIND SPEED:
RATED WIND SPEED:
RATED POWER:
CUT-OUT WIND SPEED:
ROTOR RPM:
YAWING METHOD:
ALIGNMENT (UPWIND, DOWNWIND):

WEIGHTING TOTAL:
DATE:
COMPLETED BY:

WIND ENERGY CONVERSION SYSTEM EVALUATION FORM

ITEM	CRITERIA	DATA	WEIGHTING
	GENERAL		
1.	Annual Energy Output/Annual Average Wind Speed		
2.	Design Minimum Life		
3.	Maximum Power		
4.	Power Curve		
5.	Turbine Tower Features		
6.	Standard Height at Hub or Equator		
7.	Height Option		
8.	Blade Material		
9.	Electricle System		
10.	Ambient Operating Temperature		
11.	Starting Arrangement		
	WIND SPEED		
12.	Maximum Design Wind Speed		
13.	Maximum Tested Wind Speed		
14.	Failures due to High Wind		
15.	Overspeed Control		
	SAFETY & PROTECTION		
16.	Maximum Ice Load		
17.	Ice Detection		
18.	Ice Detection Experience		

EVALUATION FORM

ITEM	CRITERIA	DATA	WEIGHTING
	SAFETY & PROTECTION (Cont'd)		
19.	Noise Level		
20.	Vibration Protection		
21.	Proximity to Dwelling		
22.	Manual Operated Brake		
23.	Lightning Protection		
24.	Skills of O & M Personnel		
25.	Service and Maintenance Equipment		
26.	Machine Evaluation		
27.	Additional Safety/Security Features		
28.	Availability Guarantee		
29.	Power Production Guarantee		
30.	Maximum Design Wind Speed Guarantee		
31.	General Guarantee		
	PHYSICAL CONSTRAINTS		
32.	Total System Weight		
33.	Weight of Heaviest Component		
34.	Length of Longest Component		
35.	Erection and Installation Equipment		
36.	Erection and Installation Assistance		

ITEM	CRITERIA	DATA	WEIGHTING
	EXPERIENCE		
37.	Number of Machines in Operation		
38.	Number of Year Model in Production		
39.	Delivery Time		
40.	Wind/Diesel Experience		
41.	Availability		
	COSTS		
42.	Turbine Cost		
43.	Erection and Installation Costs		
44.	Operation and Maintenance Costs		
45.	Total Cost		
46.	Cost of Energy		

WECS SUMMARY SHEET

MANUFACTURER: Carter Wind Systems
ADDRESS: Rt 1, Box 405-A, Burkburnett, Tex 76354
CONTACT PERSON: David Prossner
TELEPHONE NO.: (817)569-2238
TELEX:

TURBINE MODEL: 25
TYPE (VAWT, HAWT): HAWT
TURBINE DIMENSIONS: 9.75 m (32 ft.)
SWEPT (CAPTURE) AREA: 74.7 m^2 (804 $ft.^2$)
NUMBER OF BLADES: 2
CUT-IN WIND SPEED: 3.35 m/s (7.5 mph)
RATED WIND SPEED: 11.6 m/s (26 mph)
RATED POWER: 25 kW
CUT-OUT WIND SPEED: None
ROTOR RPM: not available
YAWING METHOD: Free Yaw
ALIGNMENT (UPWIND, DOWNWIND): Downwind

WEIGHTING TOTAL: 12,965
DATE: 1984 09 28
COMPLETED BY: D.H.

WIND ENERGY CONVERSION SYSTEM EVALUATION FORM

ITEM	CRITERIA	DATA	WEIGHTING
	GENERAL		
1.	Annual Energy Output/Annual Average Wind Speed	60,000 kwh @ 14 mph	
2.	Design Minimum Life	20 years	75
3.	Maximum Power	30 kW @ 30-40 mph	
4.	Power Curve	Yes	300
5.	Turbine Tower Features	Tubular guyed, self erecting	100
6.	Standard Height at Hub or Equator	60 ft.	
7.	Height Option	80 ft.	50
8.	Blade Material	Fiberglass	50
9.	Electricle System	220 or 440 volt 3 ph induction	
10.	Ambient Operating Temperature		100
11.	Starting Arrangement	self start	
	WIND SPEED		
12.	Maximum Design Wind Speed	100 mph	150
13.	Maximum Tested Wind Speed	100 mph	150
14.	Failures due to High Wind	None	300
15.	Overspeed Control	Passive pitch change mech-brake	300
	SAFETY & PROTECTION		
16.	Maximum Ice Load	Reported 3 in.	100
17.	Ice Detection		
18.	Ice Detection Experience	No	0

EVALUATION FORM

ITEM	CRITERIA	DATA	WEIGHTING
	SAFETY & PROTECTION (Cont'd)		
19.	Noise Level		300
20.	Vibration Protection	Yes auto or man reset	
21.	Proximity to Dwelling	Tower height plus 20 ft.	
22.	Manual Operated Brake	Yes from ground	500
23.	Lightning Protection		500
24.	Skills of O & M Personnel	Yes	300
25.	Service and Maintenance Equipment	Winch	800
26.	Machine Evaluation	Rocky Flats	3000
27.	Additional Safety/Security Features	Overspeed Overload protection	
28.	Availability Guarantee	Yes at extra cost	500
29.	Power Production Guarantee	No	0
30.	Maximum Design Wind Speed Guarantee	100 mph	500
31.	General Guarantee	One year	200
	PHYSICAL CONSTRAINTS		
32.	Total System Weight	3056 lbs	
33.	Weight of Heaviest Component	Tower 1960 lbs	
34.	Length of Longest Component	Tower	
35.	Erection and Installation Equipment	No special equipment	800
36.	Erection and Installation Assistance	Done by Company	25

ITEM	CRITERIA	DATA	WEIGHTING
	EXPERIENCE		
37.	Number of Machines in Operation		1500
38.	Number of Year Model in Production		0
39.	Delivery Time	less than 6 months	100
40.	Wind/Diesel Experience		0
41.	Availability	Varies	
	COSTS		
42.	Turbine Cost	$27,580 U.S.	
43.	Erection and Installation Costs	6,420	
44.	Operation and Maintenance Costs	2% of total	200
45.	Total Cost	$33,000 U.S.	
46.	Cost of Energy	C.14.1/kWh	2000

WECS SUMMARY SHEET

MANUFACTURER: Carter Wind Systems, Inc.
ADDRESS: Rt #1 Box 405A
CONTACT PERSON: David M. Prossner - Marketing
TELEPHONE NO.: Doug Parker - Engineering 817-569-2230
TELEX:

TURBINE MODEL: Carter Model 250
TYPE (VAWT, HAWT): HAWT
TURBINE DIMENSIONS: 20.57 m (67.5 ft)
SWEPT (CAPTURE) AREA: 332.4 m^2 (3578 $ft.^2$)
NUMBER OF BLADES: 2
CUT-IN WIND SPEED: 4 m/s (9 mph)
RATED WIND SPEED: 18.55 m/s (41.5 mph)
RATED POWER: 250 kW
CUT-OUT WIND SPEED: None
ROTOR RPM: 73
YAWING METHOD: Free with dampening
ALIGNMENT (UPWIND, DOWNWIND): Downwind

WEIGHTING TOTAL: 10,887
DATE: 84 10 04
COMPLETED BY: PW

WIND ENERGY CONVERSION SYSTEM EVALUATION FORM

ITEM	CRITERIA	DATA	WEIGHTING
	GENERAL		
1.	Annual Energy Output/Annual Average Wind Speed	400,000 kwh	-
2.	Design Minimum Life	20 years	75
3.	Maximum Power	280 kW	-
4.	Power Curve		300
5.	Turbine Tower Features	tapered tubular guyed tilt down	100
6.	Standard Height at Hub or Equator	160 ft.	-
7.	Height Option	No	0
8.	Blade Material	Fiberglass composite	50
9.	Electricle System	250 kW 3 Ø 480 V	-
10.	Ambient Operating Temperature	-40° to 120°F	100
11.	Starting Arrangement	Self starting	-
	WIND SPEED		
12.	Maximum Design Wind Speed	125 mph	200
13.	Maximum Tested Wind Speed	125 mph	200
14.	Failures due to High Wind	0	375
15.	Overspeed Control	coning in high speed winds, manual reset pitch change in overspeed	300
	SAFETY & PROTECTION		
16.	Maximum Ice Load		0
17.	Ice Detection	Autopsitic	-
18.	Ice Detection Experience	No problems to date on 500 units	500

EVALUATION FORM

ITEM	CRITERIA	DATA	WEIGHTING
	SAFETY & PROTECTION (Cont'd)		
19.	Noise Level	low	300
20.	Vibration Protection	none	–
21.	Proximity to Dwelling	750 ft.	
22.	Manual Operated Brake	Yes	500
23.	Lightning Protection	Yes	500
24.	Skills of O & M Personnel	Training by manufacturer	300
25.	Service and Maintenance Equipment	truck or winch, no crane needed	800
26.	Machine Evaluation	No - Rocky flats data on 24 kW	2000
27.	Additional Safety/Security Features	tilt down tower, overspeed passive cooling	
28.	Availability Guarantee	Yes	500
29.	Power Production Guarantee	No	0
30.	Maximum Design Wind Speed Guarantee	125 mph	500
31.	General Guarantee	One Year	200
	PHYSICAL CONSTRAINTS		
32.	Total System Weight	25,967 lbs	
33.	Weight of Heaviest Component	Tower 17,229 lbs	
34.	Length of Longest Component	45 ft.	
35.	Erection and Installation Equipment	Winch or truck	800
36.	Erection and Installation Assistance	Installed by manufacturer	100

ITEM	CRITERIA	DATA	WEIGHTING
	EXPERIENCE		
37.	Number of Machines in Operation	12	36
38.	Number of Year Model in Production	1 Year	50
39.	Delivery Time	3-4 months	100
40.	Wind/Diesel Experience	staff have diesel experience	0
41.	Availability	95%	
	COSTS		
42.	Turbine Cost	$264,800 U.S.	
43.	Erection and Installation Costs	$33,75 U.S. + Warranty $17,500 U.S.	
44.	Operation and Maintenance Costs		0
45.	Total Cost	$285,675 U.S.	
46.	Cost of Energy	C$0.64/kWh	2000

WECS SUMMARY SHEET

MANUFACTURER: Enertech Corporation
ADDRESS: Box 420, Norwich, VT 05055
CONTACT PERSON: David Gilmer
TELEPHONE NO.: 802-649-1145
TELEX: 706433

TURBINE MODEL: 44/40
TYPE (VAWT, HAWT): HAWT
TURBINE DIMENSIONS: Overall length 2.84 m, overall height 0.965 m, weight without blades 1,520 kg.
SWEPT (CAPTURE) AREA: 141 sq. m, solidity 0.075
NUMBER OF BLADES: Three, 6.7 m in length
CUT-IN WIND SPEED: 3.5 m/s (8 mph)
RATED WIND SPEED: 13.4 m/s (30 mph)
RATED POWER: 40kW
CUT-OUT WIND SPEED: 22.3 m/s (50 mph)
ROTOR RPM: 56.0-57.5
YAWING METHOD: Free Yaw
ALIGNMENT (UPWIND, DOWNWIND): Downwind

WEIGHTING TOTAL: 12,375
DATE: 1984 09 28
COMPLETED BY: DH

WIND ENERGY CONVERSION SYSTEM EVALUATION FORM

ITEM	CRITERIA	DATA	WEIGHTING
	GENERAL		
1.	Annual Energy Output/Annual Average Wind Speed	100,000 kWh	-
2.	Design Minimum Life	20 years	75
3.	Maximum Power	44.5 kW @ 50 mph	-
4.	Power Curve	Based on field tests to AWEA, 1982. Verified by USDA, Bushland, TX 1984 testing.	300
5.	Turbine Tower Features	Three legged, tubular steel, self-supporting, outside climbing pegs, hot galvanized.	75
6.	Standard Height at Hub or Equator	Two feet above tower top standard 80' tower, 82' hub height.	-
7.	Height Option	60', 80', 100' towers.	50
8.	Blade Material	Molded wood epoxy laminate with fiberglass covering internal and external.	50
9.	Electricle System	Three phase induction generator, 40kW, 480 VAC, 60 Hz, 1800-1840 rpm.	-
10.	Ambient Operating Temperature	-40°F to 115°F (Proven range)	100
11.	Starting Arrangement	Wind speed sensor activated contactor. Induction generator energized and motored to asynchronous speed. Start current 270 A typical Wye or Delta secondary.	-
	WIND SPEED		
12.	Maximum Design Wind Speed	120 mph	200
13.	Maximum Tested Wind Speed	90 mph, Altamont Pass, CA, November 1983.	150
14.	Failures due to High Wind	None	270
15.	Overspeed Control	Aerodynamic stall of blades, electrodynamic brake with automatic reset, disc parking brake blade tip brakes with manual reset.	300
	SAFETY & PROTECTION		
16.	Maximum Ice Load	1.5" in 100 mph wind.	100
17.	Ice Detection	Ice detection visual. Manual shut down. Manual reset.	-
18.	Ice Detection Experience	50 exposures (approximate), no failures. Typically wind sensor will ice up preventing start up of system. Blades shed ice readily.	50
		19-36 missing (Compare with other units)	6000

EVALUATION FORM

ITEM	CRITERIA	DATA	WEIGHTING
	SAFETY & PROTECTION (Cont'd)		
19.	Noise Level	44 dB	300
20.	Vibration Protection	No	-
21.	Proximity to Dwelling	125 feet	
22.	Manual Operated Brake	Yes, overide switch on face of ground mounted control box.	500
23.	Lightning Protection	Yes	500
24.	Skills of O & M Personnel	Yes	300
25.	Service and Maintenance Equipment	None	800
26.	Machine Evaluation	Yes. USDA Research Facility, Bushland, Texas, 1982-1984.	3000
27.	Additional Safety/Security Features	System shutdown due to over/under voltage, over/under frequency, thermal overload, phase loss, high winds; utility loss. Manually operated brake.	-
28.	Availability Guarantee	No	0
29.	Power Production Guarantee	No	0
30.	Maximum Design Wind Speed Guarantee	120 mph (54 m/s)	500
31.	General Guarantee	All products have a standard one-year parts and labor warranty.	200
	PHYSICAL CONSTRAINTS	Tower 80' 5870 lbs (2668 kg.) Turbine 4100 lbs. (1860 kg.)	
32.	Total System Weight		-
33.	Weight of Heaviest Component	Tower, 5870 lbs. Turbine without blades 3250 lbs.	-
34.	Length of Longest Component	2'x2" blades, 240 lbs., 8" x 20' tower legs (80' tower), 400 lbs. (approx.)	-
35.	Erection and Installation Equipment	1 15-30 ton crane with 100 ft. boom. 1 11 ft. high truck mounted platform or front end bucket for 3rd blade attachment.	400
36.	Erection and Installation Assistance	Yes, as assistance, at no additional cost.	100

ITEM	CRITERIA	DATA	WEIGHTING
	EXPERIENCE		
37.	Number of Machines in Operation	165	995
38.	Number of Year Model in Production	2 years	100
39.	Delivery Time	1 to 2 months, maximum	100
40.	Wind/Diesel Experience	7 machines, 20-30% of minimum diesel system load at maximum wind system output.	1750
41.	Availability	99%. Downtime due to maintenance and J-bolt retrofit.	1
	COSTS	With 80' tower option C $55,500 FOB Norwich, VT	-
42.	Turbine Cost		
43.	Erection and Installation Costs	C $20,500	-
44.	Operation and Maintenance Costs	1.5% of total cost.	200
45.	Total Cost	C $76,000	-
46.	Cost of Energy	C $ .76/kWh	2000

WECS SUMMARY SHEET

MANUFACTURER: Enertech Corporation
ADDRESS: Box 420, Norwich, VT 05055
CONTACT PERSON: David Gilmer
TELEPHONE NO.: 802-649-1145
TELEX: 706433

TURBINE MODEL: 44/25
TYPE (VAWT, HAWT): HAWT
TURBINE DIMENSIONS: Overall length 2.84 m, overall height 0.965 m, weight without blades 1,520 kg.
SWEPT (CAPTURE) AREA: 141 sq. m, solidity 0.075
NUMBER OF BLADES: Three, 6.7 m in length
CUT-IN WIND SPEED: 3.1 m/s (7 mph)
RATED WIND SPEED: 13.4 m/s (30 mph)
RATED POWER: 25 kW
CUT-OUT WIND SPEED: 22.3 m/s (50 mph)
ROTOR RPM: 52.0 - 53.5
YAWING METHOD: Free Yaw
ALIGNMENT (UPWIND, DOWNWIND): Downwind

WEIGHTING TOTAL: 11,413
DATE: 1984 09 28
COMPLETED BY: DH

WIND ENERGY CONVERSION SYSTEM
EVALUATION FORM

ITEM	CRITERIA	DATA	WEIGHTING
	GENERAL		
1.	Annual Energy Output/Annual Average Wind Speed	80,000 kWh	-
2.	Design Minimum Life	20 years	75
3.	Maximum Power	27 kW @ 50 mph	-
4.	Power Curve	Based on field tests to AWEA, 1982. Verified by USDA, Bushland, TX. 1982-1984 testing.	300
5.	Turbine Tower Features	Three legged, tubular steel, self-supporting, outside climbing pegs, hot galvanized.	75
6.	Standard Height at Hub or Equator	Two feet above tower top stand and 80' tower, 82' hub height.	-
7.	Height Option	60', 80', 100' towers.	60
8.	Blade Material	Moulded wood epoxy, laminate with fiberglass covering internal and external.	50
9.	Electricle System	1ϕ or 3ϕ induction generator, 35kW, nominal 230 or 460 Vac, 60 Hz, 1800-1840 rpm.	-
10.	Ambient Operating Temperature	-40°F to 115°F (proven range)	100
11.	Starting Arrangement	Wind speed sensor activated contactor. Induction generator energized and motored to synchronous speed. Start current 270A typical Wye or Delta secondary.	-
	WIND SPEED		
12.	Maximum Design Wind Speed	120 mph	200
13.	Maximum Tested Wind Speed	130 mph, Rocky Flats, Colorado	200
14.	Failures due to High Wind	None	200
15.	Overspeed Control	Aerodynamic stall of blades, electro-dynamic brake and disc parking brakes with automatic [illegible] with manual reset.	300
	SAFETY & PROTECTION		
16.	Maximum Ice Load	1.5" in 100 mph winds	100
17.	Ice Detection	Ice detection visual, manual shutdown, manual reset.	-
18.	Ice Detection Experience	10 exposures approximate, no failures. Typical wind sensor will ice up, preventing start-up of system. Blades shed ice readily.	10

EVALUATION FORM

ITEM	CRITERIA	DATA	WEIGHTING
	SAFETY & PROTECTION (Cont'd)		
19.	Noise Level	44 dB	300
20.	Vibration Protection	No	-
21.	Proximity to Dwelling	125 feet	-
22.	Manual Operated Brake	Yes, override switch on face of ground mounted control box.	500
23.	Lightning Protection	Yes	500
24.	Skills of O & M Personnel	Yes	300
25.	Service and Maintenance Equipment	None	800
26.	Machine Evaluation	Yes. USDA Research Facility, Bushland, Texas, 1982-1984.	3000
27.	Additional Safety/Security Features	System shutdown due to over/under voltage, over/under frequency, thermal overload, phase loss, high winds; utility loss. Manually operated yaw brake; tether locks.	-
28.	Availability Guarantee	No	0
29.	Power Production Guarantee	No	0
30.	Maximum Design Wind Speed Guarantee	120 mph (54 m/s)	500
31.	General Guarantee	All products have a standard one-year parts and labor warranty.	200
	PHYSICAL CONSTRAINTS		
32.	Total System Weight	Tower 80' 5870 lbs (2668 kg.) Turbine 4100 lbs. (1860 kg.)	-
33.	Weight of Heaviest Component	Tower, 5870 lbs. Turbine without blades 3250 lbs.	-
34.	Length of Longest Component	2'x2" blades, 240 lbs., 8" x 20' tower legs (80' tower), 400 lbs. (approx.)	-
35.	Erection and Installation Equipment	1 15-30 ton crane with 100 ft. boom. 1 30 ft. high truck mounted platform or front end bucket for 3rd blade attachment.	400
36.	Erection and Installation Assistance	Yes, as assistance, at no additional cost.	100

ITEM	CRITERIA	DATA	WEIGHTING
	EXPERIENCE		
37.	Number of Machines in Operation	36	108
38.	Number of Year Model in Production	3 years	150
39.	Delivery Time	3 to 4 months, maximum	100
40.	Wind/Diesel Experience	3 machines 10-15% of diesels diesel system load at maximum wind system output.	375
41.	Availability	95%. Downtime due primarily to maintenance.	-
	COSTS		
42.	Turbine Cost	80' tower option C $48,500, FOB Norwich, VT	-
43.	Erection and Installation Costs	C $19,200	-
44.	Operation and Maintenance Costs	1.5% of total cost	200
45.	Total Cost	C $67,700	-
46.	Cost of Energy	C $ .85/kWh	2000

WECS SUMMARY SHEET

MANUFACTURER: Enertech Corporation
ADDRESS: Box 420, Norwich, VT 05055
CONTACT PERSON: David Gilmer
TELEPHONE NO.: 802-649-1145
TELEX: 70643

TURBINE MODEL: 21/5
TYPE (VAWT, HAWT): HAWT
TURBINE DIMENSIONS: 2.0 m long x 0.76 m high
SWEPT (CAPTURE) AREA: 31.2 sq. m. (346 sq. ft.)
NUMBER OF BLADES: 3
CUT-IN WIND SPEED: 3.1 m/s (7 mph)
RATED WIND SPEED: 12.5 m/s (28 mph)
RATED POWER: 5 kW
CUT-OUT WIND SPEED: 50 mph
ROTOR RPM: 107.5 - 113.0
YAWING METHOD: Free Yaw
ALIGNMENT (UPWIND, DOWNWIND): Downwind

WEIGHTING TOTAL: 9,280
DATE: 1984 09 28
COMPLETED BY: DH

WIND ENERGY CONVERSION SYSTEM EVALUATION FORM

ITEM	CRITERIA	DATA	WEIGHTING
	GENERAL		
1.	Annual Energy Output/Annual Average Wind Speed	16,500 kWh	-
2.	Design Minimum Life	20 years	75
3.	Maximum Power	5.3 KW @ 36 mph	-
4.	Power Curve	Based on field tests to AWEA, 1983. Verified by Alternative Energy Institute, West Texas State University, Canyon, TX: 1984	300
5.	Turbine Tower Features	Options of three-legged, self-supporting or 3 guyed, 80' optional.	75
6.	Standard Height at Hub or Equator	15" above tower top, if 80' guyed tower, 81½' hub height.	-
7.	Height Option	60', 80', 98' towers.	60
8.	Blade Material	Moulded wood epoxy laminate with fiberglass covering (internal and external.	50
9.	Electricle System	Induction generator, 5KW, 220/240 VAC 1Ø, 60 H. 1800-1890 RPM.	-
10.	Ambient Operating Temperature	-30°F to 115°F (proven range)	100
11.	Starting Arrangement	Wind speed sensor activated contactor. Induction generator energized and motored to synchronous speed: Start current 75A typical. Wye or Delta secondary.	-
	WIND SPEED		
12.	Maximum Design Wind Speed	120 mph	200
13.	Maximum Tested Wind Speed	125 mph, Hurricane Alicia, Galveston, Texas, 1983	200
14.	Failures due to High Wind	None	375
15.	Overspeed Control	Aerodynamic stall of blades, hydraulic brake with automatic reset, blade tip brakes with manual reset.	300
	SAFETY & PROTECTION		
16.	Maximum Ice Load	3/4" at 100 mph.	0
17.	Ice Detection	75 exposures (approximate), no failures	-
18.	Ice Detection Experience	Typically wind sensor will ice up, preventing start-up of system. Blades shed ice readily.	75

EVALUATION FORM

ITEM	CRITERIA	DATA	WEIGHTING
	SAFETY & PROTECTION (Cont'd)		
19.	Noise Level	42 dB	300
20.	Vibration Protection	No	—
21.	Proximity to Dwelling	125 feet	-
22.	Manual Operated Brake	Yes, over-ride switch on face on ground mounted control box.	500
23.	Lightning Protection	Yes	500
24.	Skills of O & M Personnel	Yes	300
25.	Service and Maintenance Equipment	None	500
26.	Machine Evaluation	Yes, Alternative Energy Institute, West Texas State University, Canyon, TX, 1984.	2000
27.	Additional Safety/Security Features	System shutdown due to over/under voltage, over/under frequency, thermal overload, high winds, utility loss.	-
28.	Availability Guarantee	No	0
29.	Power Production Guarantee	No	0
30.	Maximum Design Wind Speed Guarantee	120 mph (54 m/s)	500
31.	General Guarantee	All products have a standard one-year parts and labor warranty.	200
	PHYSICAL CONSTRAINTS	Tower (80' self-supporting 3400 lbs.) Turbine 700 lbs. (317.5 Kg.)	-
32.	Total System Weight	80' self-supporting 3400 lbs. 80' guyed 1500 lbs.	-
33.	Weight of Heaviest Component	Guyed tower - 10' sections. Self-supporting tower 20' leg.	-
34.	Length of Longest Component	Erection can be done either with a gin pole and winch assembly or a 15 ton crane with 100' boom.	800
35.	Erection and Installation Equipment	Yes, as assistance, at no additional cost.	100
36.	Erection and Installation Assistance		

ITEM	CRITERIA	DATA	WEIGHTING
	EXPERIENCE		
37.	Number of Machines in Operation	60	180
38.	Number of Year Model in Production	3 years	150
39.	Delivery Time	1 to 3 months	100
40.	Wind/Diesel Experience	2 machines - penetration less than 2%.	40
41.	Availability	99%. Downtime all due to maintenance	-
	COSTS	80 ' guyed tower - C $12,500 80' guyed tower - C$12,900 80' self-supporting tower C $12,900	
42.	Turbine Cost	FOB Norwich, VT	-
43.	Erection and Installation Costs	: $ 6200	-
44.	Operation and Maintenance Costs	2.5% of total cost	0
45.	Total Cost	: $ 19,100	-
46.	Cost of Energy	: $1.16/kWh	1000

MECS SUMMARY SHEET

MANUFACTURER: Windtech
ADDRESS: Box 837, Glastonbury, CT 06033
CONTACT PERSON: M.C. Cheney
TELEPHONE NO.: (203) 659-3786
TELEX:

TURBINE MODEL: 120
TYPE (VAWT, HAWT): HAWT
TURBINE DIMENSIONS: 15.24 m Tower 10 m Rotor (50 ft. Tower 33 ft. Rotor)
SWEPT (CAPTURE) AREA: 79.4 m² (855 ft.²)
NUMBER OF BLADES: 2
CUT-IN WIND SPEED: 4 m/s (9 mph)
RATED WIND SPEED: 13.4 m/s (30 mph)
RATED POWER: 20 kW
CUT-OUT WIND SPEED: 55 m/s (125 mph)
ROTOR RPM: 130
YAWING METHOD: Free
ALIGNMENT (UPWIND, DOWNWIND): Downwind

WEIGHTING TOTAL: 8137
DATE: 84 10 04
COMPLETED BY: PW

WIND ENERGY CONVERSION SYSTEM
EVALUATION FORM

ITEM	CRITERIA	DATA	WEIGHTING
	GENERAL		
1.	Annual Energy Output/Annual Average Wind Speed	46,000 kWh	-
2.	Design Minimum Life	25 years	100
3.	Maximum Power	20 kW/35 mph	-
4.	Power Curve	Based on field tests by DOE	300
5.	Turbine Tower Features	Tapered steel, free standing	75
6.	Standard Height at Hub or Equator	50 ft.	-
7.	Height Option	Not currently	0
8.	Blade Material	Fiberglass	50
9.	Electricle System	20 kW Induction, 480 V, 3Ø	-
10.	Ambient Operating Temperature	-30°F to 110°F	100
11.	Starting Arrangement	Self Starting	-
	WIND SPEED		
12.	Maximum Design Wind Speed	125 mph	200
13.	Maximum Tested Wind Speed	150 mph	200
14.	Failures due to High Wind		375
15.	Overspeed Control	Brake/stall	300
	SAFETY & PROTECTION		
16.	Maximum Ice Load	Tested with 3/8" ice	0
17.	Ice Detection	Visual, vibration	-
18.	Ice Detection Experience	Tested with 3/8", no failure	0

EVALUATION FORM

ITEM	CRITERIA	DATA	WEIGHTING
	SAFETY & PROTECTION (Cont'd)		
19.	Noise Level	64 dbA	0
20.	Vibration Protection	Switch, manual reset	–
21.	Proximity to Dwelling	500 ft.	–
22.	Manual Operated Brake	Brake applied with off switch	500
23.	Lightning Protection	Tower ground	500
24.	Skills of O & M Personnel	Standard Mech. & Elect. skills	300
25.	Service and Maintenance Equipment	Standard tools, winch and A frame to lower machine	800
26.	Machine Evaluation	15 & 25 kW Versions of Rocky Flats 1980 v. 1982	0
27.	Additional Safety/Security Features	Overspeed, under/over voltage under/over frequency, over current	
28.	Availability Guarantee	Not in 1984 but planned for 1985	0
29.	Power Production Guarantee	No	0
30.	Maximum Design Wind Speed Guarantee	125 mph	500
31.	General Guarantee	5 year	1000
	PHYSICAL CONSTRAINTS		
32.	Total System Weight	3500 lb	–
33.	Weight of Heaviest Component	tower/2000 lb	–
34.	Length of Longest Component	tower/48 ft	–
35.	Erection and Installation Equipment	Winch and A Frame	800
36.	Erection and Installation Assistance	Installation can be provided by manufacturer	25

ITEM	CRITERIA	DATA	WEIGHTING
	EXPERIENCE		
37.	Number of Machines in Operation	4	12
38.	Number of Year Model in Production	0	0
39.	Delivery Time	4 Mo	100
40.	Wind/Diesel Experience	None	0
41.	Availability	90% projected	–
	COSTS	U.S $28,000 FOB Factory	
42.	Turbine Cost		–
43.	Erection and Installation Costs	U.S. $3,500	–
44.	Operation and Maintenance Costs	U.S. $600/yr.	0
45.	Total Cost	U.S. $31,500	–
46.	Cost of Energy	C $0.93 /kwh	2000

WECS SUMMARY SHEET

MANUFACTURER: Windtech, Inc.
ADDRESS: Box 837 Glastonbury, CT 06033
CONTACT PERSON: M.C. Cheney
TELEPHONE NO.: (203) 659-3786
TELEX:

TURBINE MODEL: 180
TYPE (VAWT, HAWT): HAWT
TURBINE DIMENSIONS: Tower 16.7 m, Rotor 15.85 m (Tower 55 ft., Rotor 52 ft.)
SWEPT (CAPTURE) AREA: 197.3 m^2 (2,124 $ft.^2$)
NUMBER OF BLADES: 2
CUT-IN WIND SPEED: 4.47 m/s (10 mph)
RATED WIND SPEED: 15.65 m/s (35 mph)
RATED POWER: 80 kW
CUT-OUT WIND SPEED: 55.9 m/s (125 mph)
ROTOR RPM: 97
YAWING METHOD: Free
ALIGNMENT (UPWIND, DOWNWIND): DW

WEIGHTING TOTAL: 9003
DATE: 1984 10 04
COMPLETED BY: PW

WIND ENERGY CONVERSION SYSTEM EVALUATION FORM

ITEM	CRITERIA	DATA	WEIGHTING
	GENERAL		
1.	Annual Energy Output/Annual Average Wind Speed	140,000	
2.	Design Minimum Life	25 yrs.	100
3.	Maximum Power	80 kW/35 mph	-
4.	Power Curve	Based on field tests by DOE	100
5.	Turbine Tower Features	Tapered steel, free standing	75
6.	Standard Height at Hub or Equator	55 ft.	-
7.	Height Option	75 ft.	50
8.	Blade Material	Fiber Glass	50
9.	Electricle System	80 kW induction 480 V, 3Ø	-
10.	Ambient Operating Temperature	-30° F to 110° F	100
11.	Starting Arrangement	Self Starting	-
	WIND SPEED		
12.	Maximum Design Wind Speed	125 mph	200
13.	Maximum Tested Wind Speed	150 mph	200
14.	Failures due to High Wind	0	375
15.	Overspeed Control	Brake, stall	300
	SAFETY & PROTECTION		
16.	Maximum Ice Load	Tested @ 3/8" ice	0
17.	Ice Detection	Visual vibration	-
18.	Ice Detection Experience	Tested @ 3/8", No failure	0

EVALUATION FORM

ITEM	CRITERIA	DATA	WEIGHTING
	SAFETY & PROTECTION (Cont'd)		
19.	Noise Level	64 dbA at 125 ft. (5 machines)	0
20.	Vibration Protection	Switch, manual reset	
21.	Proximity to Dwelling	500 ft.	-
22.	Manual Operated Brake	Brake applied with off switch	500
23.	Lightning Protection	Tower Ground	500
24.	Skills of O & M Personnel	Standard mech/elec skills	300
25.	Service and Maintenance Equipment	Standard tools, winch/a frame to lower machine	800
26.	Machine Evaluation	15 kw & 1980-1982 25 kW versions at Rocky Flats	0
27.	Additional Safety/Security Features	overspeed, under/over volt under/over freq., over current	-
28.	Availability Guarantee	Not in 1984 but planned for 1985	0
29.	Power Production Guarantee	No	0
30.	Maximum Design Wind Speed Guarantee	125 mph	500
31.	General Guarantee	5 years	1000
	PHYSICAL CONSTRAINTS		
32.	Total System Weight	10,000 lbs	—
33.	Weight of Heaviest Component	Trans. 2500 lbs. tower 5000 lbs	-
34.	Length of Longest Component	Trans/6 ft., Rotor/52 ft., tower 51 ft.	
35.	Erection and Installation Equipment	Winch/a frame	800
36.	Erection and Installation Assistance	Installation can be provided by manufact.	25

ITEM	CRITERIA	DATA	WEIGHTING
	EXPERIENCE		
37.	Number of Machines in Operation	156	100
38.	Number of Year Model in Production	100	50
39.	Delivery Time	4 MO after order (except if inventory)	100
40.	Wind/Diesel Experience	CO GEN W/150 kW Diesel Gen	10
41.	Availability	90% Projected	-
	COSTS		
42.	Turbine Cost	(FOB Factory) $50,000 - $3,000 depend on	—
43.	Erection and Installation Costs	Install approx. $5,000	—
44.	Operation and Maintenance Costs	$1,000/yr	200
45.	Total Cost	$58,000	—
46.	Cost of Energy	C$0.56/kWh	2000

WECS SUMMARY SHEET

MANUFACTURER: DAF Indal Ltd.
ADDRESS: 3570 Hawkestone Rd., Mississauga, Ontario L5C 2V8
CONTACT PERSON: Lawrence Schlenbein, Vince Lacey
TELEPHONE NO.: 1-416-275-5100 (X146)(X223)
TELEX: 06-961482

TURBINE MODEL: Series 1300 - 50 kW
TYPE (VAWT, HAWT): VAWT
TURBINE DIMENSIONS: Rotor Height - 16.8 m (55.1')
Equator Diameter - 11.2 m (36.7')
SWEPT (CAPTURE) AREA: 121 m^2 (1300 ft^2)
NUMBER OF BLADES: 2
CUT-IN WIND SPEED: 6.3 m/s (14 mph)
RATED WIND SPEED: 17.3 m/s (38.7 mph)
RATED POWER: 50 kW
CUT-OUT WIND SPEED: Shut-down @ 20 m/s (44.7 mph)
ROTOR RPM: 80
YAWING METHOD: not required
ALIGNMENT (UPWIND, DOWNWIND): not applicable

WEIGHTING TOTAL: 11.028
DATE: 84 10 04
COMPLETED BY: PW

REPLIES TO SHAWINIGAN INQUIRY - EVALUATION FORM

Series 1300 - 50 kW VAWT

(Weighting)

1. (a) Annual Average Wind Speed = 22.5 kph (14 mph).
74.8×10^3 kWh (ground level power module)
89.4×10^3 kWh (power module on 22 ft. tower)
(b) Annual Average Wind Speed = 25.8 kph (16 mph).
103.5×10^3 kWh (ground level power module)
(c) Annual Average Wind Speed = 29.0 kph (18 mph)
130.0×10^3 kWh (ground level power module) (-)

Assumptions
(i) Rayleigh Distribution
(ii) 100% Availability
(iii) Air Density = 1.225 kg/m^3
(iv) Wind Shear Power Law Exponent = 0.16

2. 20 years. (75)

3. 52 kW @ 72.0 kph (44.7 mph). (-)

4. The power vs. windspeed curve has been verified by Southern California Edison (Reference "Demonstration Testing of the DAF Indal Ltd. 50 kW Vertical Axis Wind Turbine Generator - A Fourteen Month Experience" (attached)). A lack of data in the high wind ranges is responsible for the poor correlation between the theoretical and actual curves. (300)

5. Turbine rotor features: (65)
(a) 3 guy system.
(b) Two piece painted steel column - flanged connection at mid-rotor
- external ladder

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(c) Two blades, each constructed of 2 extruded aluminum blade sections.

(d) Blade chord 0.36 m (1.17'), NACA 0015.

(e) Rotor dimensions - height 16.8 m (55.1') w/o power module
- width 11.2 m (36.7')

(f) Upper and lower struts located 16.4 m (53.3') and 6.3 m (20.3') above the ground.

6. Equator Height (power module at ground level) - 11.3 m (36.7'). (-)

7. Lattice style tower in three heights: (60)

(a) 2.1 m (6.9')
(b) 4.3 m (13.9')
(c) 6.5 m (21.0')

8. 6061-T6 extruded aluminum. (0)

9. (a) One squirrel cage induction generator rated @ 65 kVA.
(b) 575 VAC, 3 phase, 60 Hz, 1200 rpm (maximum output power is 75 HP @ 1210 rpm). (-)

10. -40°C to 50°C (-40°F to 122°F). (100)

11. During the start the following sequence occurs: (-)

(a) The hydraulic and lubrication pumps start.
(b) When the control system senses that the main gear/brake disc is clear of the brakes the contactors for the generator close.
(c) In "wye" the generator accelerates the rotor to approximately 48 rpm (720 rpm at the high speed shaft), maximum current draw is 100A.

(d) The contactors open and the rotor accelerates to full speed under wind power.

(e) When the rotor reaches full speed - 80 rpm (1200 rpm at the high speed shaft) the contactors close and the VAWT begins to generate power.

12. 242 kph (150 mph). (200)

13. 161 kph (100 mph). (150)

14. None. (450)

15. If an overspeed situation develops there are two methods of automatically sensing the overspeed and initiating a shutdown. (300)

(a) Electronic overspeed sensing.
(b) Centrifugal dump valve.

In both cases the hydraulic system is immediately depressurized causing the brakes to be applied. Since an overspeed event indicates a failure, the trip must be manually reset by a maintainer to ensure that the problem is properly addressed.

16. Three inches (76 mm) in 85 mph (140 kph). This is consistent with a planned CSA code. (200)

17. There are no direct means of preventing the VAWT from starting, or of stopping it, in the event of an excessive ice buildup. Experience with 50 kW VAWTs in Churchill, Manitoba and Sudbury, Ontario, have indicated that one of two things will happen during a start. The rotor will begin to rotate: (-)

(a) causing the ice to be thrown off of the machine; or

(b) the ice buildup on the blades will prevent the VAWT from reaching the required speed in the required time. This will cause a non-resettable trip.

In the event of an ice buildup during operation the ice will gradually degrade the ability of the blades to produce lift. This causes the VAWT to shut down. In some cases the anemometer will ice up at the same time as the blades. Another start will not be requested because the control system will be registering 0 mph.

18. The experiences listed above have occurred approximately 10 times, on two machines during the past three years. There have been no failures related to ice accumulation. (2)

19. The following data has been extracted from a report titled "First Evaluation Report on the DAF Indal Ltd. 50 kW Vertical Axis Wind Turbine Generator". The report was prepared by Southern California Edison Company based on a study of the DAF Indal Series 1300 VAWT at the Test Site near Palm Springs. (300)

Distance (Ft.)	Noise Level (dB)
100	56 to 58
200	47 to 50
400	42 to 44

20. A vibration sensor is available as an option. (-)

21. 125 m (406.3').

(-)

22. The standard braking sequence can be initiated manually by pressing a STOP button inside the power module or by turning a key switch at a remote stop/start station. (500)

23. Lightning protection is available as an option. (200)

24. Yes. (300)

25. None. All of the critical hardware is at ground level if the module is ground level mounted. (800)

26. Yes.

(a) Southern California Edison Wind Turbine Generator Test Site, Palm Springs, California, 1982-1984, on-going. (3000)

(b) California Department of Water Resources, San Luis Reservoir, California, 1982-1984.

(c) National Research Council; 1978-1984, on-going Christopher Point, B.C., Churchill, Manitoba, Holyrood, Nfld.

(d) Electricity Supply Board, Ireland, 1981-1984, on-going (-)

27. (a) The failsafe braking system is "driven" by the weight of the rotor and the tension in the guy system. Loss of the grid stops the hydraulic pump and opens the solenoid valve which results in the braking system being activated.

(b) The axial motion permitted by the lower rotor bearings ensures constant guy tension despite changes in length due to temperature variations.

(c) The centrifugal dump valve, which provides overspeed protection, is completely independent of all other protection systems. (-)

(d) Over/under voltage protection.
(e) Generator over temperature protection.

(500)

28. Yes - 90% availability is guaranteed based on DAF Indal providing the O & M services. The customer can purchase the unit without worrying that the machine will not pay back due to extended downtime.

(500)

29. Yes - the actual power curve is guaranteed to be within 97% of the published power curve. The customer can purchase the unit without worrying that the machine will not pay back due to poor performance.

(500)

30. Yes - 242 kph (150 mph). Environment Canada records and documents windspeed data from across Canada. Based on this data a 100 year return maximum windspeed is calculated. The customer can purchase the machine knowing that it has been designed to survive winds exceeding the maximum Canadian 100 year return value.

31. 5 years parts and labour on major components (rotor, bullgear). (1000)
1 year parts and labour on the balance of the components.

32. (a) Power Module (-)
(i) Weight - 4,080 kg (9,000 lb.)
(ii) Dimensions (L x W x H) - 2.1 x 2.1 x 2.8 m
(7.0' x 7.0' x 9.2')

(b) Rotor Assembled
(i) Weight - 3,675 kg (8,100 lb.)
(ii) Dimensions (L x W x H) - 1.0 x 11.3 x 17.4 m
(3.4' x 36.7' x 56.7')

(c) Rotor Disassembled
(i) Weight - 3,630 kg (8,000 lb.)
(ii) Dimensions - 1 crate - 10.8 x 1.8 x 0.6 m
(35.0' x 6.0' x 2.0')
- 1 crate - 9.2 x 1.8 x 0.9 m
(30.0' x 6.0' x 3.0')

(d) Tower Assembled
(i) One Section - Weight - 470 kg (1,035 lb.)
- Dimensions (L x W x H)
2.8 x 2.8 x 2.1 m
(9' x 9' x 6.9')
(ii) Two Section - Weight - 1,065 kg (2,350 lb.)
- Dimension (L x W x H)
3.7 x 3.7 x 4.3 m
(12' x 12' x 13.9')
(iii) Three Section - Weight - 1,725 kg (3,800 lb.)
- Dimensions (L x W x H)
4.5 x 4.5 x 6.5 m
(14.5' x 14.5' x 21')

(e) Tower Disassembled
(i) One Section - Weight - 470 kg (1,035 lb.)
- Dimensions (L x W x H)
2.5 x 0.6 x 0.6 m
(8' x 2' x 2')
(ii) Two Section - Weight - 1,065 kg (2,350 lb.)
- Dimensions (L x W x H)
4.6 x 0.6 x 0.6 m
(15' x 2' x 2')
(iii) Three Section - Weight - 1,725 kg (3,800 lb.)
- Dimensions (L x W x H)
7.1 x 0.6 x 0.6 m
(23' x 2' x 2')

33. Power Module - 4,080 kg (9,000 lb.) (0)

34. Blade Assemblies (lower)

(a) Dimensions (L x W x H) - 10.8 x 1.4 x 0.6 m (35.0' x 4.5' x 2.0') (0)

(b) Weight - 190 kg (420 lb.)

Note: Blades can be "nested" for shipment resulting in only a slight increase in the crated dimension for the four units.

35. (a) Backhoe } digging, pouring foundation and anchors
(b) Cement Truck }

(c) The height of the power module will determine the capacity of the crane and the boom length which is required to erect the rotor. A 25 ton unit with a 70 foot boom can be used for a ground level power module. If the power module is on a three section tower a 35 ton unit with a 100 foot boom is necessary. If a small capacity crane (10 ton, 35 foot boom) is available it will be adequate for moving components on the site and positioning the power module.

(d) A three ton come-a-long chain hoist.

(e) An assortment of slings, clevises and heavy rope.

Note: An alternate method of installation, not requiring a crane, has been assessed. To date this method has not been attempted. It is only feasible for a power module mounted at ground level. Details of this method can be made available. (400)

36. No. $6,000 - Supervisor provided by DAF Indal.
$10,000 - 3 Man Assembly Crew (25)

37. 7. (21)

38. 5 years. (250)

39. 6 months (100)

40. 3. (a) Rottnest Island, Australia
(b) Churchill, Manitoba
(c) Sudbury Wind/Diesel Test Site (30)

41. Of the seven (7) machines mentioned in (37), one is being used for intermittent testing. The operating data on two others is very limited. The availability of the four units which are operating constantly is as follows:

(a) Southern California Edison Wind Turbine Generator Test Site, Palm Springs, California (from March, 1982 to May 1983) - 93.6%.

(b) National Research Council, Christopher Point, British Columbia (from March 1981 to May 1983) - 87.7%

(c) National Research Council, Churchill, Manitoba (from November 1981 to May 1983) - 63.8%.

(d) National Research Council, Holyrood, Newfoundland (from June 1982 to May 1983) - 86.0%.

The primary reason for downtime has been the amount of time required to get parts and/or service personnel to the site, all of which could be considered distant to the factory. In all cases, but two, the amount of time to actually effect the repairs was less than two days once parts and personnel were on the site. (-)

42. $160,000 CDN
Tower not included - one section $6,400 CDN
- two section $8,600 CDN
- three section $10,800 CDN (-)

43. $40,000 CDN (foundation design, hardware, foundation and guy anchors, assembly and erection, electrical connections to transformer (supplied by others), DAF Indal supervision) (-)

44. 2% of capital cost. (200)

45. (a) $160,000 + $40,000 = $200,000 CDN (without tower)
(b) $200,000 + $6,400 = $206,400 CDN (one section tower)
(c) $200,000 + $8,600 = $208,600 CDN (two section tower)
(d) $200,000 + $10,800 = $210,800 CDN (three section tower) (-)

46. (a) Annual AVerage Wind Speed = 22.5 kph (14 mph) (500)

(i) Without Tower = $\$200{,}000 / 74.8 \times 10^3$ kWhr
= $2.63 kWhr

(ii) With three section tower = $\$210{,}800 / 89.4 \times 10^3$ kWh
= $2.36/kWhr

(b) For Annual Average Wind Speed = 25.8 kph (16 mph)
Without Tower = $\$200{,}000 / 103.5 \times 10^3$ kWh = $1.93/kWhr

(c) Annual Average Wind Speed = 29.0 kph (18 mph)
Without Tower = $\$200{,}000 / 130.0 \times 10^3$ kWhr = $1.53/kWhr

47. <u>Horizontal Area Required</u> (0)

Assuming level terrain:

	Total Height (m(Ft))	Guy Circle Diameter (m(Ft))	Guy Circle Area (m^2(Ft^2))
(a) ground mounted	20.2 (65.7)	57.8 (187.7)	2620 (27670)
(b) one section tower	22.3 (72.6)	63.8 (207.4)	3200 (33784)
(c) two section tower	24.5 (79.6)	70.0 (227.4)	3845 (40614)
(d) three section tower	26.8 (87.1)	76.6 (248.8)	4600 (48617)

On uneven terrain the following guidelines define the guy anchor locations:

(i) guy spacing - $120^\circ \pm 5^\circ$
(ii) guy angle - $35^\circ \pm 2^\circ$
(iii) guy length - (total height / tan 35°) ± 15% (Ht.)

In order to facilitate assembly of the rotor an area approximately 31 m (100') long by 25 m (80') wide is required adjacent to the power module. This area should be level to within 4°.

WECS SUMMARY SHEET

MANUFACTURER: DAF Indal Ltd.
ADDRESS: 3570 Hawkestone Rd., Mississauga, Ontario L5C 2V8
CONTACT PERSON: Lawrence Schienbein, Vince Lacey
TELEPHONE NO.: 1-416-275-5300 (X146)(X223)
TELEX: 06-961482

TURBINE MODEL: Series 6400 - 500 kW
TYPE (VAWT, HAWT): VAWT
TURBINE DIMENSIONS: Rotor Height - 36.6 m (120 ft.)
Equator Diameter - 24.4 m (80 ft.)
SWEPT (CAPTURE) AREA: 595 m^2 (6400 ft^2)
NUMBER OF BLADES: 2
CUT-IN WIND SPEED: 6.0 m/s (13.4 mph)
RATED WIND SPEED: 18.2 m/s (40.7 mph)
RATED POWER: 522 kW
CUT-OUT WIND SPEED: Shut-down @ 24.0 m/s (53.7 mph)
ROTOR RPM: 45 RPM
YAWING METHOD: not required
ALIGNMENT (UPWIND, DOWNWIND): not applicable

WEIGHTING TOTAL: 10,198
DATE: 84 10 04
COMPLETED BY: PW

REPLIES TO SHAWINIGAN INQUIRY - EVALUATION FORM

Series 6400 - 500 kW VAWT

(Weighting)

1.(a) Annual Average Wind Speed = 22.5 kph (14 mph). (-)
638.1×10^3 kWhr

(b) Annual Average Wind Speed = 25.8 kph (16 mph).
921.4×10^3 kWhr

(c) Annual Average Wind Speed = 29.0 kph (18 mph).
1196.2×10^3 kWhr

Assumptions

(i) Rayleigh Distribution
(ii) 100% Availability
(iii) Air Density = 1.225 kg/m^3
(iv) Wind Shear Power Law Exponent = 0.16

2. 20 years. (75)

3. 592 kW @ 88.2 kph (53.7 mph). (-)
(300)

4. The windspeed vs. power curve is based on theoretical predictions using the double multiple stream tube model with dynamic stall. The actual curve is being determined by field tests of two Series 6400 - 500 kW VAWTs. The method being used complies with AWEA and CSA Standards and with the IEA standard except for the averaging period used. Data will probably be available before the end of 1986.
(65)

5. Turbine rotor features:

(a) Six guy system (3 pairs of two).

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(b) Two piece painted steel column - flanged connection at mid-rotor
- external ladder

(c) Two blades, each constructed of 3 extruded aluminum blade sections.

(d) Blade chord - 0.74 m (2.42'), NACA 0015.

(e) Rotor dimensions - height 36.6 m (120.0') w/o power module
- width 24.4 m (80.0')

(f) Upper and lower struts located 10.8 m (35.0') and 32.9 m (107.0') from ground level.

(0)

6. Equator Height - 21.85 m (71.0').

( )

7. Although a final tower design has not been completed, enough work had been done to indicate that DAF Indal would be willing to mount a 500 kW on a tower. The maximum height being 9.2 m (30 ft.).

(0)

8. 6061-T6 extruded aluminum.

9. (a) Two squirrel cage induction generators rated @ 337.7 kVA (second generator operates only in high winds).

(b) 440 VAC, 3 phase, 60 Hz, 720 rpm (maximum continuous output power is 266 kW @ 735 rpm). (-)

10. -30°C to 45°C (-22°F to 113°F). (100)

11. During the start the following sequence occurs: (-)

(a) The hydraulic and lubrication pumps start.

(b) When the control system senses that the main gear/brake disc is clear of the brakes, and that the lubricant flow, the hydraulic pressure and the guy system tension are correct, the contactors for the #1 generator close.

(c) In "wye" the #1 generator accelerates the rotor to approximately 30 rpm (480 rpm at the high speed shaft), maximum current draw is 600A.

(d) The contactors open and the rotor accelerates to full speed under wind power.

(e) When the rotor reaches full speed - 45 rpm (720 rpm at the high speed shaft) the #1 contactors close and the VAWT begins to generate power.

(200)

12. 242 kph (150 mph).

(150)

13. 162 kph (100 mph).

(600)

14. None.

15. If an overspeed situation develops there are two methods of automatically sensing the overspeed and initiating a shutdown.

(a) Electronic overspeed sensing.

(b) Centrifugal dump valves (2 in parallel).

In both cases the hydraulic system is immediately depressurized causing the brakes to be applied. Since an overspeed event indicates a failure, the trip must be manually reset by a maintainer to ensure that the problem is properly addressed. (300)

16. Three inches (76 mm) in 85 mph (140 kph). This is consistent with a planned CSA code. (200)

17. There are no direct means of preventing the VAWT from starting, or of stopping it, in the event of an excessive ice buildup. Experience with the 50 kW VAWTs in Churchill, Manitoba and Sudbury, Ontario, have indicated that one of two things will happen during a start. The rotor will begin to rotate: (-)

(a) causing the ice to be thrown off of the machine; or

(b) the ice buildup on the blades will prevent the VAWT from reaching the required speed in the required time. This will cause a non-resettable trip.

In the event of an ice buildup during operation the ice will gradually degrade the ability of the blades to produce lift. This causes the VAWT to shut down. In some cases the anemometer will ice up at the same time as the blades. Another start will not be requested because the control system will be registering 0 mph.

18. The experiences listed above have occurred approximately 10 times, on two machines during the past three years. There have been no failures related to ice accumulation. (2)

19. A study conducted for the Electrical Power Research Institute (EPRI) recorded the noise level of 65 dBA (@ 2000 Hz) at a distance of 77.0 m (250 ft.) (0)

20. No.

21. 265 m (861.0'). (-)

22. No. A manually activated brake would be impractical on a machine of this size. The standard braking sequence can be initiated manually by pressing a STOP button inside the power module or turning a key switch at a remote stop/start station. (0)

23. Southern California Edison (SCE) has installed lightning protection for its 500 kW unit. (200)

24. Yes. (300)

25. None. All of the critical hardware is at ground level. (800)

26. Yes - Atlantic Wind Test Site (AWTC) North Cape, Prince Edward Island, 1984 - ongoing
Southern California Edison Wind Turbine Generator Test Site, Palm Springs, California, 1983/1984 - ongoing. (3000)

27. (a) The failsafe braking system is "driven by the weight of the rotor and the tension in the guy system. Loss of the grid stops the hydraulic pump which results in the braking system being activated. (-)

(b) The axial motion permitted by the upper and lower rotor bearings ensures constant guy tension despite changes in length due to temperature variations.

(c) The centrifugal dump valves, which provide overspeed protection, are completely independent of all other control systems.

(d) Lubricant flow and hydraulic system pressures are monitored to ensure safe operation.

(e) Over/under voltage protection.

(f) Generator over temperature protection.

28. Yes - 90% availability is guaranteed based on DAF Indal providing the O & M services. The customer can purchase the unit without worrying that the machine will not pay back due to extended downtime. (500)

29. Yes - the actual power curve is guaranteed to be within 97% of the published power curve. The customer can purchase the unit without worrying that the machine will not pay back due to poor performance. (500)

30. Yes - 245 kph (150 mph). Environment Canada records and documents windspeed data from across Canada. Based on this data a 100 year return maximum windspeed is calculated. The customer can purchase the machine knowing that it has been designed to survive winds exceeding the maximum Canadian 100 year return value. (500)

31. 5 years parts and labour on major components (rotor, bull-gear). 1 year parts and labour on the balance of the components. (1000)

32. (a) Power Module (-)

(i) Weight - 20,860 kg (46,000 lb.)

(ii) Dimensions (L x W x H) - 3.0 x 3.6 x 3.4 m (9'10" x 11'8" x 11'0")

(b) Rotor Assembled

(i) Weight - 19,950 kg (44,000 lb.)

(ii) Dimensions (L x W x H) - 2.3 x 24.4 x 38.5 m (7'6" x 80'0" x 125'0")

(c) Rotor Disassembled

(i) Weight - 19,950 kg (44,000 lb.)

(ii) Dimensions (L x W x H) - 2.0 x 3.1 x 3.4 m (65' x 10' x 11')

33. Power Module - 20,860 kg (46,000 lb.) (-)

34. Column Half (-)

(a) Dimensions - 19.3 m (62'6") Long
- 1.7 m (5'6") Maximum Diameter (Tapered)

(b) Weight - 6,800 kg (15,000 lb.)

35. (0)

(a) Backhoe } digging, pouring foundation & anchors
(b) Cement Trucks }

(c) 1 - 100 ton crane with 150 foot boom } assembly and erection
(d) 1 - 40 ton crane with 50 foot boom }

(e) at least two 5 ton "come-a-longs" (chain hoists)

(f) one truck with winch capabilities

(g) assortment of slings, clevises, heavy rope

Note: Alternate methods of installation have been assessed, to reduce the required capacity of the largest crane. To date these methods have not been attempted.

36. No. $12,000 CDN Supervisor provided by DAF Indal (0)
$20,000 CDN 3 Man Assembly Crew

37. 2 machines. (6)

38. 2 years. (100)

39. 6 months. (100)

40. None. (0)

41. (a)(i) Unit 001 (SCE) - 65.5% (-)
(ii) Unit 002 (NRC) - 81.4%

(b) Primary reasons for downtime

(i) hydraulic leak (since repaired) Unit 001

(ii) defective pump (since repaired) Unit 001

(iii) pinions insufficiently hardened. Units 001 & 002.

42. $600,000 CDN. (-)

43. $125,000 CDN (foundation design, hardware, foundation and guy anchors, assembly and erection, electrical connections to transformer (supplied by others), DAF Indal supervision). (-)

44. 2% of total cost. (200)

45. $600,000 + $125,000 = $725,000 CDN. (-)

46. (a) Annual Average Wind Speed = 22.5 kph (14 mph) (1000)
$\$725,000/638.1 \times 10^3$ kWh = $1.14 per kWh

(b) Annual Average Wind Speed = 25.8 kph (16 mph)
$\$725,000/921.4 \times 10^3$ kWh = $0.79 per kWh

(c) Annual Average Wind Speed = 29.0 kph (18 mph)
$\$725,000/1196.2 \times 10^3$ kWh = $0.61 per kWh

47. <u>Horizontal Area Required</u>

Based on a total height of 41.5 m (135 ft.) and a guy angle of 35° the guy cables will encompass a circular area 119 m (386 ft.) in diameter assuming flat terrain. The following guidelines govern the installation of a VAWT on uneven terrain.

(i) guy spacing - $120^\circ \pm 5^\circ$
(ii) guy angle - $35^\circ \pm 2^\circ$
(iii) guy length - 72.3 m (235 ft.) ± 15%

A further constraint must be imposed to ensure that there is an adequate area in which to assemble the rotor. This area, which must be adjacent to the power module, must be at least 50 m (160 ft.) long by 37 m (120 ft.) wide with an overall slope of not greater than 4°.

DAF INDAL LTD

WECS SUMMARY SHEET

MANUFACTURER: M.A.N. - GHH (Canada) Inc.
ADDRESS: Suite 210, 6600 Trans Canada, Point-Claire, Quebec H9R 4S2
CONTACT PERSON: F.J. Langbau
TELEPHONE NO.: (514) 694-3000
TELEX: 05-822644

TURBINE MODEL: AEROMAN 33
TYPE (VAWT, HAWT): HAWT
TURBINE DIMENSIONS: 12.5 m (41 ft.)
SWEPT (CAPTURE) AREA: 123 m² (1321 ft.²)
NUMBER OF BLADES: 2
CUT-IN WIND SPEED: 3.7 m/s (8.3 mph)
RATED WIND SPEED: 11.85 m/s (26.4 mph)
RATED POWER: 33 kW
CUT-OUT WIND SPEED: none
ROTOR RPM: 100
YAWING METHOD: Fan tail
ALIGNMENT (UPWIND, DOWNWIND): Upwind

WEIGHTING TOTAL: 10.265
DATE: 84 10 12
COMPLETED BY: PW

WIND ENERGY CONVERSION SYSTEM EVALUATION FORM

ITEM	CRITERIA	DATA	WEIGHTING
	GENERAL		
1.	Annual Energy Output/Annual Average Wind Speed	approx. 75 MWh at 6.25 m/s average (14 mph)	
2.	Design Minimum Life	20 years	75
3.	Maximum Power	33 kW at 11.8 m/s (26.4 mph)	
4.	Power Curve	calculated and compared with test results	300
5.	Turbine Tower Features	free standing conical central steel pipe, 15 m (33.6 ft)	75
6.	Standard Height at Hub or Equator	16 m / 53 ft	-
7.	Height Option	10 m / 32.8 ft	50
8.	Blade Material	Glasfiber Reinforced Plastics (GFRP)	50
9.	Electricle System	Induction generator, 3-phase, 33 kW, 480 VAC, 60 Hz, 1.800 rpm	
10.	Ambient Operating Temperature	- 25°C + 40°C	100
11.	Starting Arrangement	Automatically self-starting at 3.7 m/s (8.3 mph)	
	WIND SPEED		
12.	Maximum Design Wind Speed	50 m/s, 112 mph	150
13.	Maximum Tested Wind Speed	47 m/s, 105 mph	150
14.	Failures due to High Wind	None	375
15.	Overspeed Control	electronically controlled blade feathering, disc brake and centrifugal controlled overspeed-shut-down manual reset	300
	SAFETY & PROTECTION		
16.	Maximum Ice Load	approx. 30 mm when not in operation, 45 N/m² app. wind speed	100
17.	Ice Detection	Vibration Detector, manual reset	-
18.	Ice Detection Experience	Up to now no shut-down at approx. 10 mm ice-load	0

EVALUATION FORM

ITEM	CRITERIA	DATA	WEIGHTING
	SAFETY & PROTECTION (Cont'd)		
19.	Noise Level	44 dB(A) at 20 m downwind and 8 m/s windspeed (18 mph)	300
20.	Vibration Protection	Yes, manual reset	–
21.	Proximity to Dwelling	80 m / 265 ft	–
22.	Manual Operated Brake	Yes, actuated from tower base	500
23.	Lightning Protection	Yes, by grounding of the tower	500
24.	Skills of O & M Personnel	Yes	300
25.	Service and Maintenance Equipment	None, in some special cases a mobile crane 1.5 to 20 m	800
26.	Machine Evaluation	Diagnostic Centre at Schnittlingen 1983/1984 German test field at Pellworm 1983, GKSS	2000
27.	Additional Safety/Security Features	Emergency cut-off by means of a disk-brake in case of overspeed, Vibrations detector, blade feathering, consumer control / Automatic grid-cut-in/cut-out	-
28.	Availability Guarantee	To negotiate	0
29.	Power Production Guarantee	According 'output characteristics' (see folder)	0
30.	Maximum Design Wind Speed Guarantee	Yes, 50 m/s, 112 mph	500
31.	General Guarantee	Standard 6 months parts and labour warranty	100
	PHYSICAL CONSTRAINTS		
32.	Total System Weight	3.950 kg , 8.700 lbs including tower	–
33.	Weight of Heaviest Component	Tower: 1.100 kg / 2.000 lbs (one half) Nacelle: 1.100 kg / 2.600 lbs	–
34.	Length of Longest Component	approx. 8 m for 1 half of the tower, ca. 1.400 kg / 1.000 lbs	-
35.	Erection and Installation Equipment	crane, 20 m / 65 ft, 1.5 to	600
36.	Erection and Installation Assistance	Yes, 850,-- DM* per man and day additional costs	25

* Basis 1984

ITEM	CRITERIA	DATA	WEIGHTING
	EXPERIENCE		
37.	Number of Machines in Operation	18 additional 95 at the end of 1984	50
38.	Number of Year Model in Production	2	100
39.	Delivery Time	6 months from receipt of order	100
40.	Wind/Diesel Experience	5 machines, up to 80 % of minimum system load	800
41.	Availability	60 %, downtimes primarily due to assembly shops and lead times for customs	–
	COSTS		–
42.	Turbine Cost	ca. DM 95,000.--	
43.	Erection and Installation Costs	ca. DM 15,000.--	–
44.	Operation and Maintenance Costs	4 % of No. 42	0
45.	Total Cost	ca. DM 110,000.--	0
46.	Cost of Energy	C$0.65/kWh	2000
47.	Pitch control	Speed and power control by means of blade pitch adjustment	0
48.	Design certificate by an independent certification society	Actually proven by Germanischer Lloyd	0
49.	Automatic start-up after grid failure	Automatic grid cut-in/cut-out control unit	0

WECS SUMMARY SHEET

MANUFACTURER: JACOBS WIND ELECTRIC COMPANY
ADDRESS: 2720 Fernbrook Lane, Minneapolis, MN 55441
CONTACT PERSON: Ken Lampert
TELEPHONE NO.: (612)559-9361
TELEX: 290 435

TURBINE MODEL: 26-17.5
TYPE (VAWT, HAWT): HAWT
TURBINE DIMENSIONS: 8.0 m (26 ft.)
SWEPT (CAPTURE) AREA: 49.2 m² (530 ft.²)
NUMBER OF BLADES: 3
CUT-IN WIND SPEED: 3.6 m/s (8.0 mph)
RATED WIND SPEED: 12.2 m/s (27 mph)
RATED POWER: 17.5 kW
CUT-OUT WIND SPEED: N.A.
ROTOR RPM: 215
YAWING METHOD: Tailvane
ALIGNMENT (UPWIND, DOWNWIND): UPWIND

WEIGHTING TOTAL: 11,380
DATE: 84 10 04
COMPLETED BY: PW

WIND ENERGY CONVERSION SYSTEM
EVALUATION FORM

ITEM	CRITERIA	DATA	WEIGHTING
	GENERAL		
1.	Annual Energy Output/Annual Average Wind Speed	36511 KW Hrs @ 23 KPH (14.3 MPH) - IND	-
2.	Design Minimum Life	20 YEARS	75
3.	Maximum Power	17.5 KW @ 27 MPH	-
4.	Power Curve	SEE PRODUCT INFORMATION - PAGE 6	0
5.	Turbine Tower Features	3 POST FREE STANDING, TUBULAR, LATTICE, GALVANIZED, STEP BOLTS ON LEG, OPTIONAL CLIMB.	60 CABLE
6.	Standard Height at Hub or Equator	80 FEET (24 M)	-
7.	Height Option	60 FEET (18 M), 100 FEET (30 M), 120 FEET (36 M), 140 FEET (42 M).	60
8.	Blade Material	LAMINATED WOOD -- SITKA SPRUCE	50
9.	Electricle System	25 KVA BRUSHLESS, 3Ø, SYNCHONOUS 0-180 VAC, 0-40 Hz	-
10.	Ambient Operating Temperature	-20 to 40° C - STANDARD BELOW -20° C - SPECIAL LUBRICANTS	100
11.	Starting Arrangement	AERODYNAMICALLY SELF STARTING	-
	WIND SPEED		
12.	Maximum Design Wind Speed	120 MPH (54 M/S)	200
13.	Maximum Tested Wind Speed	80-100 MPH - UNDER TEST 100 MPH + - OPERATING EXPERIENCE	150
14.	Failures due to High Wind	NONE	360
15.	Overspeed Control	CENTRIFUGAL GOVERNOR - ROTOR RPM HYPOID DRIVE/FOLDING TAILVANE - FURL	300
	SAFETY & PROTECTION		
16.	Maximum Ice Load	1/2", 50 P.S.F., E.I.A. STANDARD RS-222C	0
17.	Ice Detection	NONE	-
18.	Ice Detection Experience	100+ EXPERIENCES, NO FAILURES	100

EVALUATION FORM

ITEM	CRITERIA	DATA	WEIGHTING
	SAFETY & PROTECTION (Cont'd)		
19.	Noise Level	2 DB ABOVE BACKGROUND (74 VS 72 DB) 21.6 MPH WIND/300 FROM WIND PLANT	300
20.	Vibration Protection	NONE	–
21.	Proximity to Dwelling	60 M or 2x TOWER HEIGHT	–
22.	Manual Operated Brake	MAINTENANCE - DISC BRAKE ACTUATED @ TOWER BASE	500
23.	Lightning Protection	YES (REF: OWNERS MANUAL - SECT 3.9 - 3.12)	500
24.	Skills of O & M Personnel	YES	300
25.	Service and Maintenance Equipment	NONE	800
26.	Machine Evaluation	DOE - ROCKY FLATS	3000
27.	Additional Safety/Security Features	UNDERVOLTAGE, OVERVOLTAGE, FREQUENCY TOLERANCE	–
28.	Availability Guarantee	NO	0
29.	Power Production Guarantee	NO	0
30.	Maximum Design Wind Speed Guarantee	YES - 75 MPH (34 M/S)	500
31.	General Guarantee	1 YEAR - PARTS	200
	PHYSICAL CONSTRAINTS	WIND TURBINE 1940 # TOWER/ANCHORS 3260# INVERTER/CIRCUIT 240#	
32.	Total System Weight		–
33.	Weight of Heaviest Component	790 LBS - STUB TOWER	–
34.	Length of Longest Component	20' TOWER LEG	–
35.	Erection and Installation Equipment	MOBILE CRANE - 25 TON CAPACITY 100' REACH	600
36.	Erection and Installation Assistance	1) AVAILABLE THROUGH DISTRIBUTOR 2) FACTORY TECHNICAL SUPPORT AVAILABLE @ $500/ DAY + EXPENSES	25

ITEM	CRITERIA	DATA	WEIGHTING
	EXPERIENCE		
37.	Number of Machines in Operation	OVER 600	1500
38.	Number of Year Model in Production	4 YEARS	200
39.	Delivery Time	10-12 WEEKS	100
40.	Wind/Diesel Experience	APPROXIMATELY 20 SYSTEMS, % PENETRATION VARIES	200
41.	Availability	95+ %, DOWNTIME DUE TO SERVICE & MAINTENANCE	–
	COSTS		
42.	Turbine Cost	,ME 26-17.5, 80' (D) TOWER/ANCHORS, MEP - 17, $ 29,260.00 U.S., F.O.B. MFG	–
43.	Erection and Installation Costs	$5,000.00	–
44.	Operation and Maintenance Costs	2 % OF SYSTEM COST	200
45.	Total Cost	$34,260.00	–
46.	Cost of Energy	C$1.26/kWh	1000

WECS SUMMARY SHEET

MANUFACTURER: JACOBS WIND ELECTRIC COMPANY
ADDRESS: 2720 Fernbrook Lane, Minneapolis, MN 55441
CONTACT PERSON: Ken Lampert
TELEPHONE NO.: (612)559-9361
TELEX: 290 435

TURBINE MODEL: 24-15
TYPE (VAWT, HAWT): HAWT
TURBINE DIMENSIONS: 7.3 m (24 ft.)
SWEPT (CAPTURE) AREA: 42 m² (452 ft.²)
NUMBER OF BLADES: 3
CUT-IN WIND SPEED: 3.6 m/s (8.0 mph)
RATED WIND SPEED: 12.3 m/s (28.0 mph)
RATED POWER: 15 kW
CUT-OUT WIND SPEED: Unit will operate continuously up to design wind speed of 54 m/s.
ROTOR RPM: 220
YAWING METHOD: Tailvane
ALIGNMENT (UPWIND, DOWNWIND): UPWIND

WEIGHTING TOTAL: 11,380
DATE: 84 10 04
COMPLETED BY: PW

WIND ENERGY CONVERSION SYSTEM EVALUATION FORM

ITEM	CRITERIA	DATA	WEIGHTING
	GENERAL		
1.	Annual Energy Output/Annual Average Wind Speed	20696 KW Hrs @ 23 KPH (14.3 MPH) - HUB	-
2.	Design Minimum Life	20 YEARS	75
3.	Maximum Power	15 KW @ 28 MPH	-
4.	Power Curve	SEE PRODUCT INFORMATION - PAGE 6	0
5.	Turbine Tower Features	3 POST FREE STANDING, TUBULAR, LATTICE, GALVANIZED, STEP BOLTS ON LEG, OPTIONAL CLIMB	60 ABLE
6.	Standard Height at Hub or Equator	80 FEET (24 M)	-
7.	Height Option	60 FEET (18 M), 100 FEET (30 M), 120 FEET (36 M), 140 FEET (42 M).	60
8.	Blade Material	LAMINATED WOOD -- SITKA SPRUCE	50
9.	Electricle System	25 KVA BRUSHLESS, 3Ø, SYNCHONOUS 0-180 VAC, 0-40 Hz	-
10.	Ambient Operating Temperature	-20 to 40° C - STANDARD BELOW -20° C - SPECIAL LUBRICANTS	100
11.	Starting Arrangement	AERODYNAMICALLY SELF STARTING	-
	WIND SPEED		
12.	Maximum Design Wind Speed	120 MPH (54 M/S)	200
13.	Maximum Tested Wind Speed	80-100 MPH - UNDER TEST 100 MPH + - OPERATING EXPERIENCE	150
14.	Failures due to High Wind	NONE	360
15.	Overspeed Control	CENTRIFUGAL GOVERNOR - ROTOR RPM HYPOID DRIVE/FOLDING TAILVANE - FURL	300
	SAFETY & PROTECTION		
16.	Maximum Ice Load	1/2", 50 P.S.F., E.I.A. STANDARD RS-222C	0
17.	Ice Detection	NONE	-
18.	Ice Detection Experience	100+ EXPERIENCES, NO FAILURES	100

EVALUATION FORM

ITEM	CRITERIA	DATA	WEIGHTING
	SAFETY & PROTECTION (Cont'd)		
19.	Noise Level	2 DB ABOVE BACKGROUND (74 VS 72 DB) 21.6 MPH WIND/300 FROM WIND PLANT	300
20.	Vibration Protection	NONE	–
21.	Proximity to Dwelling	60 M or 2x TOWER HEIGHT	–
22.	Manual Operated Brake	MAINTENANCE - DISC BRAKE ACTUATED @ TOWER BASE	500
23.	Lightning Protection	YES (REF: OWNERS MANUAL - SECT 3.9 - 3.12)	500
24.	Skills of O & M Personnel	YES	300
25.	Service and Maintenance Equipment	NONE	800
26.	Machine Evaluation	DOE - ROCKY FLATS	3000
27.	Additional Safety/Security Features	UNDERVOLTAGE, OVERVOLTAGE, FREQUENCY TOLERANCE	–
28.	Availability Guarantee	NO	0
29.	Power Production Guarantee	NO	0
30.	Maximum Design Wind Speed Guarantee	YES - 75 MPH (34 M/S)	500
31.	General Guarantee	1 Year - parts	200
	PHYSICAL CONSTRAINTS	WIND TURBINE - 1925# TOWER/ANCHORS - 2930# INVERTER/CHOKE - 240#	
32.	Total System Weight		–
33.	Weight of Heaviest Component	790 LBS - STUB TOWER	–
34.	Length of Longest Component	20' TOWER LEG	–
35.	Erection and Installation Equipment	MOBILE CRANE - 25 TON CAPACITY 100' REACH	600
36.	Erection and Installation Assistance	1) AVAILABLE THROUGH DISTRIBUTOR 2) FACTORY TECHNICAL SUPPORT AVAILABLE @ $500/ DAY + EXPENSES	25

ITEM	CRITERIA	DATA	WEIGHTING
	EXPERIENCE		
37.	Number of Machines in Operation	OVER 600	1500
38.	Number of Year Model in Production	4 YEARS	200
39.	Delivery Time	10-12 WEEKS	100
40.	Wind/Diesel Experience	APPROXIMATELY 20 SYSTEMS, % PENETRATION VARIES	200
41.	Availability	95+ %, DOWNTIME DUE TO SERVICE & MAINTENANCE	–
	COSTS	JWE 24-15, 80' (C) TOWER/ANCHOR, HEP - 15	–
42.	Turbine Cost	$ 25,010.00	
43.	Erection and Installation Costs	$5,000.00	0
44.	Operation and Maintenance Costs	2 % OF SYSTEM COST	200
45.	Total Cost	$ 30,010.00	–
46.	Cost of Energy	C$1.41	1000

WECS SUMMARY SHEET

MANUFACTURER: JACOBS WIND ELECTRIC COMPANY
ADDRESS: 2720 Fernbrook Lane, Minneapolis, MN 55441
CONTACT PERSON: Ken Lampert
TELEPHONE NO.: (612)559-9361
TELEX: 290 435

TURBINE MODEL: 23-12.5
TYPE (VAWT, HAWT): HAWT
TURBINE DIMENSIONS: 7.1 m (23 ft.)
SWEPT (CAPTURE) AREA: 38.5 m² (415 ft.²)
NUMBER OF BLADES: 3
CUT-IN WIND SPEED: 3.6 m/s (8.0 mph)
RATED WIND SPEED: 12.0 m/s (27.0 mph)
RATED POWER: 12.5 kW
CUT-OUT WIND SPEED: Unit will operate continuously up to design wind speed of 54 m/s.
ROTOR RPM: 205
YAWING METHOD: Tailvane
ALIGNMENT (UPWIND, DOWNWIND): UPWIND

WEIGHTING TOTAL: 11,380
DATE: 84 10 04
COMPLETED BY: PW

WIND ENERGY CONVERSION SYSTEM EVALUATION FORM

ITEM	CRITERIA	DATA	WEIGHTING
	GENERAL		
1.	Annual Energy Output/Annual Average Wind Speed	26079 KW Hrs @ 23 KPH (14.3 MPH) - IBM	—
2.	Design Minimum Life	20 YEARS	75
3.	Maximum Power	12.5 KW @ 27 MPH	0
4.	Power Curve	SEE PRODUCT INFORMATION - PAGE 6	—
5.	Turbine Tower Features	3 POST FREE STANDING, TUBULAR, LATTICE, GALVANIZED, STEP BOLTS ON LEG, OPTIONAL CLIMB CABLE	60
6.	Standard Height at Hub or Equator	80 FEET (24 M)	—
7.	Height Option	60 FEET (18 M), 100 FEET (30 M), 120 FEET (36 M), 140 FEET (42 M)	60
8.	Blade Material	LAMINATED WOOD - SITKA SPRUCE	50
9.	Electricle System	25 KVA BRUSHLESS, 3Ø, SYNCHONOUS 0-180 VAC, 0-40 Hz	—
10.	Ambient Operating Temperature	-20 to 40° C - STANDARD BELOW -20° C - SPECIAL LUBRICANTS	100
11.	Starting Arrangement	AERODYNAMICALLY SELF STARTING	—
	WIND SPEED		
12.	Maximum Design Wind Speed	120 MPH (54 M/S)	200
13.	Maximum Tested Wind Speed	80-100 MPH - UNDER TEST 100 MPH + : OPERATING EXPERIENCE	150
14.	Failures due to High Wind	NONE	360
15.	Overspeed Control	CENTRIFUGAL GOVERNOR - ROTOR RPM HYPOID DRIVE/FOLDING TAILVANE - FURL	300
	SAFETY & PROTECTION		
16.	Maximum Ice Load	1/2", 50 P.S.F., E.I.A. STANDARD RS-222C	0
17.	Ice Detection	NONE	—
18.	Ice Detection Experience	100+ EXPERIENCES, NO FAILURES	100

EVALUATION FORM

ITEM	CRITERIA	DATA	WEIGHTING
	SAFETY & PROTECTION (Cont'd)		
19.	Noise Level	2 DB ABOVE BACKGROUND (74 VS 72 DB) 21.6 MPH WIND/300' FROM WIND PLANT	300
20.	Vibration Protection	NONE	—
21.	Proximity to Dwelling	60 M or 2x TOWER HEIGHT	—
22.	Manual Operated Brake	MAINTENANCE - DISC BRAKE ACTUATED @ TOWER BASE	500
23.	Lightning Protection	YES (REF: OWNERS MANUAL - SECT 3.9 - 3.12)	500
24.	Skills of O & M Personnel	YES	300
25.	Service and Maintenance Equipment	NONE	800
26.	Machine Evaluation	DOE - ROCKY FLATS	3000
27.	Additional Safety/Security Features	UNDERVOLTAGE, OVERVOLTAGE, FREQUENCY TOLERANCE	—
28.	Availability Guarantee	NO	0
29.	Power Production Guarantee	NO	0
30.	Maximum Design Wind Speed Guarantee	YES - 75 MPH (34 M/S)	500
31.	General Guarantee	1 YEAR - PARTS	200
	PHYSICAL CONSTRAINTS	WIND TURBINE 1900# TOWER/ANCHORS 2930# INVERTER/CHOKE 240#	
32.	Total System Weight		—
33.	Weight of Heaviest Component	790 LBS - STUB TOWER	—
34.	Length of Longest Component	20' TOWER LEG	—
35.	Erection and Installation Equipment	MOBILE CRANE - 25 TON CAPACITY 100' REACH	800
36.	Erection and Installation Assistance	1) AVAILABLE THROUGH DISTRIBUTOR 2) FACTORY TECHNICAL SUPPORT AVAILABLE @ $500/ DAY + EXPENSES	25

ITEM	CRITERIA	DATA	WEIGHTING
	EXPERIENCE		
37.	Number of Machines in Operation	OVER 600	1500
38.	Number of Year Model in Production	4 YEARS	200
39.	Delivery Time	10-12 WEEKS	100
40.	Wind/Diesel Experience	APPROXIMATELY 20 SYSTEMS, % PENETRATION VARIES	200
41.	Availability	95+ %, DOWNTIME DUE TO SERVICE & MAINTENANCE	-
	COSTS	JWE 23-12.6, 80' (C) TOWER/ANCHOR, HEP - 12.5	
42.	Turbine Cost	$22,110 U.S., F.O.B. MFG.	—
43.	Erection and Installation Costs	$5,000.00	—
44.	Operation and Maintenance Costs	2 % OF SYSTEM COST	200
45.	Total Cost	$27,100.00	—
46.	Cost of Energy	C$1.40	1000

WECS SUMMARY SHEET

MANUFACTURER: JACOBS WIND ELECTRIC COMPANY
ADDRESS: 2720 Fernbrook Lane, Minneapolis, MN 55441
CONTACT PERSON: Ken Lampert
TELEPHONE NO.: (612)559-9361
TELEX: 290 435

TURBINE MODEL: 23-10
TYPE (VAWT, HAWT): HAWT
TURBINE DIMENSIONS: 7.1 m (23 ft.)
SWEPT (CAPTURE) AREA: 38.5 m² (415 ft.²)
NUMBER OF BLADES: 3
CUT-IN WIND SPEED: 3.6 m/s (8.0 mph)
RATED WIND SPEED: 11.2 m/s (25.0 mph)
RATED POWER: 10 kW
CUT-OUT WIND SPEED: Unit will operate continuously up to design wind speed of 54 m/s.
ROTOR RPM: 200
YAWING METHOD: Tailvane
ALIGNMENT (UPWIND, DOWNWIND): UPWIND

WEIGHTING TOTAL: 11,380
DATE: 84 10 04
COMPLETED BY: PW

WIND ENERGY CONVERSION SYSTEM EVALUATION FORM

ITEM	CRITERIA	DATA	WEIGHTING
	GENERAL		
1.	Annual Energy Output/Annual Average Wind Speed	24767 KW Hrs @ 23 KPH (14.3 MPH) - INUB	-
2.	Design Minimum Life	20 YEARS	75
3.	Maximum Power	10 KW @ 25 MPH	-
4.	Power Curve	SEE PRODUCT INFORMATION - PAGE 6	0
5.	Turbine Tower Features	3 POST FREE STANDING, TUBULAR, LATTICE, GALVANIZED, STEP BOLTS ON LEG, OPTIONAL CLIMB	60
6.	Standard Height at Hub or Equator	80 FEET (24 M)	-
7.	Height Option	60 FEET (18 M), 100 FEET (30 M), 120 FEET (36 M), 140 FEET (42 M),	60
8.	Blade Material	LAMINATED WOOD -- SITKA SPRUCE	50
9.	Electricle System	25 KVA BRUSHLESS, 3ϕ, SYNCHRONOUS 0-180 VAC, 0-40 Hz	-
10.	Ambient Operating Temperature	-20 to 40° C - STANDARD BELOW -20° C - SPECIAL LUBRICANTS	100
11.	Starting Arrangement	AERODYNAMICALLY SELF STARTING	-
	WIND SPEED		
12.	Maximum Design Wind Speed	120 MPH (54 M/S)	200
13.	Maximum Tested Wind Speed	80-100 MPH - UNDER TEST 100 MPH + - OPERATING EXPERIENCE	150
14.	Failures due to High Wind	NONE	160
15.	Overspeed Control	CENTRIFUGAL GOVERNOR - ROTOR RPM HYPOID DRIVE/FOLDING TAILVANE - FURL	300
	SAFETY & PROTECTION		
16.	Maximum Ice Load	1/2", 50 P.S.F., E.I.A. STANDARD RS-222C	0
17.	Ice Detection	NONE	-
18.	Ice Detection Experience	100+ EXPERIENCES, NO FAILURES	100

EVALUATION FORM

ITEM	CRITERIA	DATA	WEIGHTING
	SAFETY & PROTECTION (Cont'd)		
19.	Noise Level	2 DB ABOVE BACKGROUND (74 VS 72 DB) 21.6 MPH WIND/300 FROM WIND PLANT	300
20.	Vibration Protection	NONE	—
21.	Proximity to Dwelling	60 M or 2x TOWER HEIGHT	—
22.	Manual Operated Brake	MAINTENANCE - DISC BRAKE ACTUATED @ TOWER BASE	500
23.	Lightning Protection	YES (REF: OWNERS MANUAL - SECT 3.9 - 3.12)	500
24.	Skills of O & M Personnel	YES	300
25.	Service and Maintenance Equipment	NONE	800
26.	Machine Evaluation	DOE - ROCKY FLATS	3000
27.	Additional Safety/Security Features	UNDERVOLTAGE, OVERVOLTAGE, FREQUENCY TOLERANCE	—
28.	Availability Guarantee	NO	0
29.	Power Production Guarantee	NO	0
30.	Maximum Design Wind Speed Guarantee	YES - 75 MPH (34 M/S)	500
31.	General Guarantee	ONE YEAR- PARTS	200
	PHYSICAL CONSTRAINTS	WIND TURBINE - 1900# TOWER/ANCHORS - 2930# INVERTER/CHOKE - 240 #	
32.	Total System Weight		—
33.	Weight of Heaviest Component	790 LBS - STUB TOWER	—
34.	Length of Longest Component	20' TOWER LEG	—
35.	Erection and Installation Equipment	MOBILE CRANE - 25 TON CAPACITY 100' REACH	600
36.	Erection and Installation Assistance	1) AVAILABLE THROUGH DISTRIBUTOR 2) FACTORY TECHNICAL SUPPORT AVAILABLE @ $500/ DAY + EXPENSES	25

ITEM	CRITERIA	DATA	WEIGHTING
	EXPERIENCE		
37.	Number of Machines in Operation	OVER 600	1500
38.	Number of Year Model in Production	4 YEARS	200
39.	Delivery Time	10-12 WEEKS	100
40.	Wind/Diesel Experience	APPROXIMATELY 20 SYSTEMS, 5 PENETRATION VARIES	200
41.	Availability	95+ %, DOWNTIME DUE TO SERVICE & MAINTENANCE	—
	COSTS	JUE 23-10, 80' (C) TOWER/ANCHOR, HEP-10	
42.	Turbine Cost	$20,210.00 U.S., F.O.B. MFG	—
43.	Erection and Installation Costs	$5,000.00	—
44.	Operation and Maintenance Costs	2 % OF SYSTEM COST	2x3
45.	Total Cost	$25,210.00	—
46.	Cost of Energy	[illegible]	1000

WECS SUMMARY SHEET

MANUFACTURER: North Wind Power Company, Inc.
ADDRESS: P.O. Box 556, Moretown, Vt. 05660
CONTACT PERSON: Allan Russell
TELEPHONE NO.: (802) 496-2955
TELEX: 957034

TURBINE MODEL: L-916
TYPE (VAWT, HAWT): Haut
TURBINE DIMENSIONS: 9 m
SWEPT (CAPTURE) AREA: 65.6 m² (706.5 ft.²)
NUMBER OF BLADES: 2
CUT-IN WIND SPEED: 3.13 m/s (7 mph)
RATED WIND SPEED: 12.5 m/s (28 mph)
RATED POWER: 16 kW
CUT-OUT WIND SPEED: 25 m/s (56 mph)
ROTOR RPM: 150
YAWING METHOD: Passive, w/tail
ALIGNMENT (UPWIND, DOWNWIND): Downwind

WEIGHTING TOTAL: 11,016
DATE: 84 10 04
COMPLETED BY: PW

WIND ENERGY CONVERSION SYSTEM EVALUATION FORM

ITEM	CRITERIA	DATA	WEIGHTING
	GENERAL		
1.	Annual Energy Output/Annual Average Wind Speed	42,000 @ 14 mph annual average	–
2.	Design Minimum Life	20 Years	75
3.	Maximum Power	16	–
4.	Power Curve	Based on testing, Rockr Flats, AWEA, Vt.	300
5.	Turbine Tower Features	Lattice, self-support, tilting option available.	60
6.	Standard Height at Hub or Equator	60'	–
7.	Height Option	80 or 100'	50
8.	Blade Material	Birch laminate employing West epoxy	50
9.	Electricle System	Direct drive 150 rpm synchronous	–
10.	Ambient Operating Temperature	-30°C to 60°C	100
11.	Starting Arrangement	Self starting	–
	WIND SPEED		
12.	Maximum Design Wind Speed	125 mph, steady	200
13.	Maximum Tested Wind Speed	105 mph	150
14.	Failures due to High Wind	-0-	600
15.	Overspeed Control	Passive feathering, automatically employed on loss of grid, manual, or vibration, all automatic reset.	300
	SAFETY & PROTECTION		
16.	Maximum Ice Load	.75"	300
17.	Ice Detection	Vibration sensor only	–
18.	Ice Detection Experience	Numerous exposures, no failures reported	10

EVALUATION FORM

ITEM	CRITERIA	DATA	WEIGHTING
	SAFETY & PROTECTION (Cont'd)		
19.	Noise Level	60 dB at tower base	300
20.	Vibration Protection	Yes	—
21.	Proximity to Dwelling	Same as tower height, minimum	—
22.	Manual Operated Brake	No brake, shutdown by feathering	0
23.	Lightning Protection	Yes	500
24.	Skills of O & M Personnel	Yes	300
25.	Service and Maintenance Equipment	None required	800
26.	Machine Evaluation	Yes, Rocky Flats and AWTS, U.S. Navy	1000
27.	Additional Safety/Security Features	controls monitor voltage and frequency both from grid and generator.	—
28.	Availability Guarantee	No	0
29.	Power Production Guarantee	No	0
30.	Maximum Design Wind Speed Guarantee	Yes	500
31.	General Guarantee	3 years standard	600
	PHYSICAL CONSTRAINTS		
32.	Total System Weight	1600 lbs. plus tower	—
33.	Weight of Heaviest Component	Alternator	—
34.	Length of Longest Component	Blade 15', tower 20'	—
35.	Erection and Installation Equipment	Backhoe, crane, or lifting motion	800
36.	Erection and Installation Assistance	Yes, U.S. $325/day plus direct costs	25

ITEM	CRITERIA	DATA	WEIGHTING
	EXPERIENCE		
37.	Number of Machines in Operation	12 of this model, 200+ all models	36
38.	Number of Year Model in Production	Since 1981	150
39.	Delivery Time	3 months, seasonally dependent	10
40.	Wind/Diesel Experience	60 wind/diesel/battery systems None interfaced on grids smaller than 100kW	600
41.	Availability	Early machine repairs delayed due to design or supplier changes, 4 machines 100% for [illegible]	—
	COSTS		
42.	Turbine Cost	U.S. $38,000	—
43.	Erection and Installation Costs	U.S. $10,000	—
44.	Operation and Maintenance Costs	1 Man day/year required	200
45.	Total Cost	U.S. $50,000	—
46.	Cost of Energy	C$1.6/kWh	1000

WECS SUMMARY SHEET

MANUFACTURER: AIEXTH Energy Systems Inc.
ADDRESS: 32 Rivalda Road, Weston, Ont. M9M 2H3
CONTACT PERSON: Alexander Printzios
TELEPHONE NO.: (416) 745-2416
TELEX:

TURBINE MODEL: AIEXTH-125
TYPE (VAWT, HAWT): VAWT
TURBINE DIMENSIONS: Rotor: height 25.5 m, diam. 17.0 m
SWEPT (CAPTURE) AREA: 288 m^2 (3100 ft^2)
NUMBER OF BLADES: Two (2)
CUT-IN WIND SPEED: 4.4 m/s (10 mph)
RATED WIND SPEED: 16 m/s (36 mph)
RATED POWER: 125 kW
CUT-OUT WIND SPEED: 18 m/s (40 mph)
ROTOR RPM: 46
YAWING METHOD: Not required
ALIGNMENT (UPWIND, DOWNWIND): Not applicable.

WEIGHTING TOTAL: 81/5
DATE: 84 10 12
COMPLETED BY: P.W.

WIND ENERGY CONVERSION SYSTEM EVALUATION FORM

ITEM	CRITERIA	DATA	WEIGHTING
	GENERAL		
1.	Annual Energy Output/Annual Average Wind Speed	270,000 kwh @ 14 mph	-
2.	Design Minimum Life	30 years	125
3.	Maximum Power	125 kw @ 16 m/s (36 mph)	-
4.	Power Curve	Double Multiple Stream Tube Theory (R.J. Templin) Corrected for mechanical and electrical losses	300
5.	Turbine Tower Features	Lattice, steel, supported by external frame hot galvanized	50
6.	Standard Height at Hub or Equator	25.5 m (84 ft)	-
7.	Height Option	N/A	0
8.	Blade Material	Multi-element Extruded Aluminum Alloy 6351-T6	0
9.	Electricle System	Induction Generator 125 kw, 575 VAC, 3 phase, 60 Hz, 1825 rpm	-
10.	Ambient Operating Temperature	-30 degrees C to 40 degrees C (-22 F to 104 F)	100
11.	Starting Arrangement	Wye-Delta Starter	-
	WIND SPEED		
12.	Maximum Design Wind Speed	125 mph (56 m/sec)	200
13.	Maximum Tested Wind Speed	N/A	0
14.	Failures due to High Wind	N/A	0
15.	Overspeed Control	Mechanical Brake, Fail-Safe Aerodynamic Overspeed Control	300
	SAFETY & PROTECTION		
16.	Maximum Ice Load	25mm @ 80 km/hr wind	0
17.	Ice Detection		-
18.	Ice Detection Experience		0

EVALUATION FORM

ITEM	CRITERIA	DATA	WEIGHTING
	SAFETY & PROTECTION (Cont'd)		
19.	Noise Level	Not measured	0
20.	Vibration Protection	No	–
21.	Proximity to Dwelling	250 m (820 ft)	–
22.	Manual Operated Brake	Yes, brake applied whenever electrical powe fails	500
23.	Lightning Protection	Yes	900
24.	Skills of O & M Personnel	Yes	300
25.	Service and Maintenance Equipment	None	800
26.	Machine Evaluation	MOD-125 scheduled for installation at KVS by Atmospheric 1984 for evaluation and testin	0
27.	Additional Safety/Security Features	Automatic shutdown when upper bearing overheats	–
28.	Availability Guarantee	5 years on major structural components	0
29.	Power Production Guarantee	Yes, 90% of wind speed versus power curve	500
30.	Maximum Design Wind Speed Guarantee	Yes, contingent on satisfactory wind data availability	500
31.	General Guarantee	90% full parts and labour and major components guaranteed against defects for five years	1000
	PHYSICAL CONSTRAINTS		
32.	Total System Weight	10,900 kg (24,000 lbs)	–
33.	Weight of Heaviest Component	1,200 kg (2641 lbs) Transmission	–
34.	Length of Longest Component	45' x 2.0' x 8' (13.7 m x .6 m x 2.4 m) (369 kg) 813 lbs Blade Section	–
35.	Erection and Installation Equipment	One 5-ton crane with 50 ft. boom minimum (140 ft. desirable)	600
36.	Erection and Installation Assistance	Yes	300

ITEM	CRITERIA	DATA	WEIGHTING
	EXPERIENCE		
37.	Number of Machines in Operation	N/A	0
38.	Number of Year Model in Production	N/A	0
39.	Delivery Time	6 months	100
40.	Wind/Diesel Experience	None	0
41.	Availability	N/A	–
	COSTS	1 - 5 units - $130,000 fob 6 - 10 units - $120,000 fob 11 - 25 units - $110,000 fob	
42.	Turbine Cost		–
43.	Erection and Installation Costs	$10,000 to $25,000 depending upon site conditions	–
44.	Operation and Maintenance Costs	Estimated to be 2% of total cost	200
* 45.	Total Cost	See below *	–
46.	Cost of Energy		2000

No. Units	Cost per Unit	Cost of Energy
1 - 5	$150,000	0.56
6 - 10	$138,000	0.51
11 - 25	$125,000	0.46

* 45. Total Cost	No. Units	Total Cost
	1 - 5	$140,000 - $155,000
	6 - 10	$130,000 - $145,000
	11 - 25	$120,000 - $135,000

NSO 270,000 kwh @ 23 kph (14 mph)

WECS SUMMARY SHEET

MANUFACTURER: STORK PGO-WEB B.V. i.o.
ADDRESS: Oosterdokspermiddenstraat 62, 1018 MS Amsterdam, The Netherlands
CONTACT PERSON: E. Heinen
TELEPHONE NO.: 020 - 26 00 33
TELEX: 16107

TURBINE MODEL: HEWECS-25
TYPE (VAWT, HAWT): HAWT
TURBINE DIMENSIONS: Hight 35m ; Rotordiameter 26,5m
SWEPT (CAPTURE) AREA: 551 m²
NUMBER OF BLADES: 2
CUT-IN WIND SPEED: 6 m/s
RATED WIND SPEED: 13 m/s
RATED POWER: 300 kWe
CUT-OUT WIND SPEED: 25 m/s
ROTOR RPM: 60 - 72
YAWING METHOD: motor controlled electrical drive
ALIGNMENT (UPWIND, DOWNWIND): upwind

WEIGHTING TOTAL: 8,489
DATE: 84 10 03
COMPLETED BY: PW

WIND ENERGY CONVERSION SYSTEM EVALUATION FORM

ITEM	CRITERIA	DATA	WEIGHTING
	GENERAL		
1.	Annual Energy Output/Annual Average Wind Speed	400.000 kWh	-
2.	Design Minimum Life	25 years	75
3.	Maximum Power	300 kW at 13 m/s	-
4.	Power Curve	Based on IEA	300
5.	Turbine Tower Features	Tubular, steel, self supporting, inside ladder, painted	100
6.	Standard Height at Hub or Equator	22m pr. 35m Hub height	-
7.	Height Option	PPP. P!P?P.	50
8.	Blade Material	glass-fibre reinforced polyester	50
9.	Electricle System	AC-DC-AC, brushless compound synchronous generator; 320 kW/400 kVa at 1500 rpm and 600 kW/500 kVa at 1800 rpm	-
10.	Ambient Operating Temperature	- 30°C to 45°C	100
11.	Starting Arrangement	15A required for auxiliary systems	-
	WIND SPEED		
12.	Maximum Design Wind Speed	56 m/s	200
13.	Maximum Tested Wind Speed	25 m/s	0
14.	Failures due to High Wind	1	112
15.	Overspeed Control	aerodynamic by full span pitch control with a mechanical brake as emergency back-up	300
	SAFETY & PROTECTION		
16.	Maximum Ice Load	50 mm by 45 m/s	100
17.	Ice Detection	optional	-
18.	Ice Detection Experience	Approx. 15, no failures	15

EVALUATION FORM

ITEM	CRITERIA	DATA	WEIGHTING
	SAFETY & PROTECTION (Cont'd)		
19.	Noise Level	45 dba	300
20.	Vibration Protection	yes, manual reset	–
21.	Proximity to Dwelling	100 m	–
22.	Manual Operated Brake	Yes, override switch located in controlroom and in nacelle	500
23.	Lightning Protection	Yes	500
24.	Skills of O & M Personnel	diesel/mechanical operator with some initial training	300
25.	Service and Maintenance Equipment	None	800
26.	Machine Evaluation	Machine has been derived from ECN 25m HAT	0
27.	Additional Safety/Security Features	* see page down	–
28.	Availability Guarantee	Yes, 90%	500
29.	Power Production Guarantee	Yes, provided satisfactory windata are available	500
30.	Maximum Design Wind Speed Guarantee	Yes, 56 m/s, by falling pitch controlsystem	500
31.	General Guarantee	one year warranty on parts and labour	200
	PHYSICAL CONSTRAINTS		
32.	Total System Weight	27 ton incl tower (14 ton) for 22 m hubheight	–
33.	Weight of Heaviest Component	Tower 14t or 28 ton	–
34.	Length of Longest Component	Tower 14 ton or 28t pending on hub height	–
35.	Erection and Installation Equipment	200 ton crane 40m boom	600
36.	Erection and Installation Assistance	Yes, no additional costs	100
27	* - max. windspeed - vibration nacelle - max. rpm - max. mil amp. generator load	- high temperature generator - lubrication oil temperature - undervoltage protection	

ITEM	CRITERIA	DATA	WEIGHTING
	EXPERIENCE		
37.	Number of Machines in Operation	4; and 2 under construction	12
38.	Number of Year Model in Production	11 year for HEMD (a-35); 3 years for HAT in Delten (BLTH)	75
39.	Delivery Time	12 months	0
40.	Wind/Diesel Experience	None	0
41.	Availability	> 80%	–
	COSTS		
42.	Turbine Cost	f 850.000,-- f.o.b. Amsterdam, excl. foundation and control cabin	–
43.	Erection and Installation Costs	f 50.000,-- (estimated)	–
44.	Operation and Maintenance Costs	2% of turbine cost per year	200
45.	Total Cost	Dfl 900.000,-- f.o.b. Amsterdam, excl. foundation and control cabin	–
46.	Cost of Energy	C$ 0,703 kWh (rate of exchange C$ 1 = Dfl. 3,20)	2000

WECS SUMMARY SHEET

MANUFACTURER: MOERUP INDUSTRIAL WINDMILL COMPANY A/S
ADDRESS: Voldstrupvej 13 - Svinding, 8900 Randers-DENMARK
CONTACT PERSON: Erling Moerup
TELEPHONE NO.: 45-6-466044
TELEX: ITX 85565120

TURBINE MODEL: 60/13
TYPE (VAWT, HAWT): HAWT
TURBINE DIMENSIONS: Hub Height 23 meter
SWEPT (CAPTURE) AREA: 200 sq m
NUMBER OF BLADES: 3
CUT-IN WIND SPEED: 4 m/s (9 mph)
RATED WIND SPEED: 16 m/s (36 mph)
RATED POWER: 65 kW
CUT-OUT WIND SPEED: NONE
ROTOR RPM: 33 RPM 13 kW/48 RPM 65 kW
YAWING METHOD: Automatic - Electric Motor
ALIGNMENT (UPWIND, DOWNWIND): Upwind

WEIGHTING TOTAL: 11,091
DATE: 84 09 28
COMPLETED BY: DH

WIND ENERGY CONVERSION SYSTEM EVALUATION FORM

ITEM	CRITERIA	DATA	WEIGHTING
	GENERAL	147,000 KWH-std day-16 MPH Rayleigh (colder temperature would be higher)	
1.	Annual Energy Output/Annual Average Wind Speed		-
2.	Design Minimum Life	25 Years	100
3.	Maximum Power	65 KW - 36 MPH	-
4.	Power Curve	Field Tests in Operating Wind Farm	300
5.	Turbine Tower Features	Hot Galvanized Tubular - Steel - Self supporting - Inside Ladder	100
6.	Standard Height at Hub or Equator	75 Ft - 23 m	-
7.	Height Option	100 Ft.	-
8.	Blade Material	Aerostar Fiberglass reinforced polyester	50
9.	Electricle System	13KW 65KW 480 VAC 3 phase Induction (60HZ) 1,200 RPM	-
10.	Ambient Operating Temperature	-30°C to 45°C	100
11.	Starting Arrangement	Aerodynamic Wind Start - no power wind	-
	WIND SPEED		
12.	Maximum Design Wind Speed	50 m/s (110 mph)	150
13.	Maximum Tested Wind Speed	70 mph	0
14.	Failures due to High Wind	NONE	210
15.	Overspeed Control	Aerodynamic stall, mechanical brake, centrifugal tip brake- oil reset	300
	SAFETY & PROTECTION	Hosts Riso Std.-Aerostar Blade design ice loads being sent under separate cover from Denmark	300
16.	Maximum Ice Load		
17.	Ice Detection	Automatic shutdown for imbalance manual reset.	-
18.	Ice Detection Experience	Several - None	-

EVALUATION FORM

ITEM	CRITERIA	DATA	WEIGHTING
	SAFETY & PROTECTION (Cont'd)		
19.	Noise Level	100 meters 50DBA, 300 meters 35 DBA	300
20.	Vibration Protection	Yes - manual reset	-
21.	Proximity to Dwelling	500 feet	-
22.	Manual Operated Brake	Yes - disconnect from grid or switch at tower	500
23.	Lightning Protection	Yes	500
24.	Skills of O & M Personnel	Yes - should have basic electric knowledge	300
25.	Service and Maintenance Equipment	1-15 ton Boom Truck - 100' Boom	0
26.	Machine Evaluation	Yes Risø 1983 Yes R. Lynette & Associates enclosed	1000
27.	Additional Safety/Security Features	Grid control - unbalance - thermal relays-wear tests	-
28.	Availability Guarantee	Yes - 90% - if not available pay twice lost	500
29.	Power Production Guarantee	No -	0
30.	Maximum Design Wind Speed Guarantee	Yes -	500
31.	General Guarantee	All parts and labor - 1 year	1000
	PHYSICAL CONSTRAINTS		
32.	Total System Weight	24,000 LBS	-
33.	Weight of Heaviest Component	Nacelle 12,500 LBS	-
34.	Length of Longest Component	24' Bottom section Tower	-
35.	Erection and Installation Equipment	1 - 82 Ton Crane	600
36.	Erection and Installation Assistance	Advisory - reasonable per diem and expense	25

ITEM	CRITERIA	DATA	WEIGHTING
	EXPERIENCE		
37.	Number of Machines in Operation	22	81
38.	Number of Year Model in Production	1.5	76
39.	Delivery Time	2 months	100
40.	Wind/Diesel Experience	NONE - currently testing	0
41.	Availability	97.5	-
	COSTS		
42.	Turbine Cost	$11,000.USD;FOB Oregon	-
43.	Erection and Installation Costs	Estimate $15,000 to $25,000 (Site Specific)	-
44.	Operation and Maintenance Costs	1,500 Annually	0
45.	Total Cost	32,600 to 37,600 (Inc. duty, freight)	-
46.	Cost of Energy	CFO .60/kWh	2000

WECS SUMMARY SHEET

MANUFACTURER:	HOWDEN GROUP CANADA LTD.
ADDRESS:	1510 BIRCHMOUNT ROAD, SCARBOROUGH, ONTARIO M1P 2G6
CONTACT PERSON:	I. HOWITT
TELEPHONE NO.	(416) 752 7310
TELEX:	06 963 609
TURBINE MODEL:	HWP 60
TYPE (VAWT, HAWT):	HAWT
TURBINE DIMENSIONS:	15 m. ROTOR DIAMETER, 20 m. HUB HEIGHT
SWEPT (CAPTURE) AREA:	177 $m.^2$
NUMBER OF BLADES:	3
CUT-IN WIND SPEED:	3.7 m/s
RATED WIND SPEED:	16 m/s
RATED POWER:	60 Kw.
CUT-OUT WIND SPEED:	28 m/s
ROTOR RPM:	50 rpm.
YAWING METHOD:	ELECTRIC MOTORS, MECHANICAL LOCK
ALIGNMENT (UPWIND, DOWNWIND):	UPWIND

WEIGHTING TOTAL: 10925

DATE: 1984 12 18
COMPLETED BY: PW

WIND ENERGY CONVERSION SYSTEM
EVALUATION FORM

ITEM	CRITERIA	DATA	WEIGHING
	GENERAL		
1.	Annual Energy Output/Annual Average Wind Speed	210,000 Kw Hr. at 8 m/s	-
2.	Design Minimum Life	25 years	100
3.	Maximum Power	62 Kw at 16 m/s	-
4.	Power Curve	attached - based on IEA	300
-	Turbine Tower Features	tubular, steel, freestanding, galvanised, hinged, lower to ground for access	100
6.	Standard Height at Hub or Equator	20 m.	-
7.	Height Option	30 m.	0
8.	Blade Material	wood epoxy composite	50
9.	Electrical System	synchronous or induction 60 Kw. and 12 Kw. 60 Hz 1800 rpm	-
10.	Ambient Operating Temperature	- 30°C to 40°C.	100
11.	Starting Arrangement	self-starting	-
	WIND SPEED		
12.	Maximum Design Wind Speed	60 m/s	200
13.	Maximum Tested Wind Speed	n/a	0
14.	Failures due to High Wind	none	0
15.	Overspeed Control	centrifugal tip control plus mechanical brake, both automatic reset	300
	SAFETY & PROTECTION		
16.	Maximum Ice Load	n/a	0
17.	Ice Detection	not standard	-
18.	Ice Detection Experience	none	0

EVALUATION FORM

ITEM	CRITERIA	DATA	WEIGHTING
	SAFETY & PROTECTION (Cont'd)		
19.	Noise Level	no measurements available	0
20.	Vibration Protection	yes - auto reset	-
21.	Proximity to Dwelling	200 m.	-
22.	Manual Operated Brake	manual control at base of tower	500
23.	Lightning Protection	yes	500
24.	Skills of O & M Personnel	yes	300
25.	Service and Maintenance Equipment	small winch to lower machine to ground for maintenance	800
26.	Machine Evaluation	being carried out by N.E.L., UK national test site	2000
27.	Additional Safety/Security Features	full protection systems	-
28.	Availability Guarantee	yes - 90% of annual energy production	500
29.	Power Production Guarantee	yes - 90% of rated power	500
	Maximum Design Wind Speed Guarantee	yes - contingent on satisfactory wind data	500
31.	General Guarantee	all parts and labour for one year 5 year option at extra cost	1000
	PHYSICAL CONSTRAINTS		
32.	Total System Weight	8 tonne	-
33.	Weight of Heaviest Component	Nacelle 2.5 tonne	-
34.	Length of Longest Component	tower section 10 m. x 0.8 m.	-
35.	Erection and Installation Equipment	as in 25. above	800
	Erection and Installation Assistance	installation supervision provided at extra cost	25

ITEM	CRITERIA	DATA	WEIGHTING
	EXPERIENCE		
37.	Number of Machines in Operation	none	0
38.	Number of Year Model in Production	one	50
39.	Delivery Time	three months	100
40.	Wind/Diesel Experience	none	0
41.	Availability	n/a	-
	COSTS		
42.	Turbine Cost	$75,000	-
43.	Erection and Installation Costs	$20,000	-
44.	Operation and Maintenance Costs	$ 1,500 p.a	300
45.	Total Cost	$95,000	-
46.	Cost of Energy	$ 0.45/Kwh	2000

WECS SUMMARY SHEET

MANUFACTURER:	HOWDEN GROUP CANADA LTD.
ADDRESS:	1510 BIRCHMOUNT ROAD, SCARBOROUGH, ONTARIO M1P 2G6
CONTACT PERSON:	I. HOWITT
TELEPHONE NO.	(416) 752 7310
TELEX:	06 963 609
TURBINE MODEL:	HWP 200 (DOWNRATED 300 Kw. 22 m.)
TYPE (VAWT, HAWT):	HAWT
TURBINE DIMENSIONS:	22 m. ROTOR DIAMETER, 22 m. HUB HEIGHT
SWEPT (CAPTURE) AREA:	380 $m.^2$
NUMBER OF BLADES:	3
CUT-IN WIND SPEED:	5 m/s
RATED WIND SPEED:	14 m/s
RATED POWER:	200 Kw.
CUT-OUT WIND SPEED:	28 m/s
ROTOR RPM:	45 rpm.
YAWING METHOD:	HYDRAULIC YAW MOTORS, MECHANICAL LOCK
ALIGNMENT (UPWIND, DOWNWIND):	UPWIND

WEIGHTING TOTAL: 11147

DATE: 1984 12 18
COMPLETED BY: PW

WIND ENERGY CONVERSION SYSTEM
EVALUATION FORM

ITEM	CRITERIA	DATA	WEIGHTING
	GENERAL		
1.	Annual Energy Output/Annual Average Wind Speed	500,000 Kw. Hr. at 8 m/s	-
2.	Design Minimum Life	25 years	100
3.	Maximum Power	200 Kw. at 14 m/s	-
4.	Power Curve	attached based on IEA	100
-	Turbine Tower Features	tubular, free-standing, steel galvanised internal ladder and access	100
6.	Standard Height at Hub or Equator	22 m.	-
7.	Height Option	none	0
8.	Blade Material	wood epoxy composite	50
9.	Electrical System	synchronous or induction, 460 V. 3 phase 60 Hz 1200 rpm.	-
10.	Ambient Operating Temperature	-30°C to +40°C.	10
11.	Starting Arrangement	self-starting	-
	WIND SPEED		133
12.	Maximum Design Wind Speed	67 M/s	200
13.	Maximum Tested Wind Speed	55 m/s	150
14.	Failures due to High Wind	none	100
15.	Overspeed Control	tip suctions automatically deploy plus disc brake, both automatic reset	100
	SAFETY & PROTECTION		
16.	Maximum Ice Load	no significant ice loading todate	0
17.	Ice Detection	ice detection system non-standard	-
18.	Ice Detection Experience	no failures or icing problems todate	0

EVALUATION FORM

ITEM	CRITERIA	DATA	WEIGHTING
	SAFETY & PROTECTION (Cont'd)		
19.	Noise Level	53 dBA at 100 m. 6-7 m/s wind	300
20.	Vibration Protection	yes - auto reset	-
21.	Proximity to Dwelling	500 m.	-
22.	Manual Operated Brake	yes - manual control in tower base	500
23.	Lightning Protection	yes	500
24.	Skills of O & M Personnel	yes	300
25.	Service and Maintenance Equipment	none - built in hoist	800
26.	Machine Evaluation	yes North of Scotland Hydro Electric Board	2000
27.	Additional Safety/Security Features	full safety/security see attached specification	-
28.	Availability Guarantee	yes - 90% of annual energy production	500
29.	Power Production Guarantee	yes - 90% of rated power	500
--	Maximum Design Wind Speed Guarantee	yes - contingent on satisfactory wind data	500
31.	General Guarantee	all parts and labour for one year five year option at extra cost	1000
	PHYSICAL CONSTRAINTS		-
32.	Total System Weight	50,000 lb.	-
33.	Weight of Heaviest Component	5,000 lb. gearbox	-
34.	Length of Longest Component	10.5 m. blade	-
35.	Erection and Installation Equipment	6 ton capacity mobile crane 12 ton capacity winch 10 m. high 'A' frame	200
[illegible]	Erection and Installation Assistance	installation supervision provided at additional cost	25

ITEM	CRITERIA	DATA	WEIGHTING
	EXPERIENCE		
37.	Number of Machines in Operation	one	1
38.	Number of Year Model in Production	one	50
39.	Delivery Time	five months	100
40.	Wind/Diesel Experience	Orkney machine feeds a weak island system of diesels occasionally when mainland cable connection is out	0
41.	Availability	82%	-
	COSTS		-
42.	Turbine Cost	$ 380,000.00	
43.	Erection and Installation Costs	$ 73,000.00	-
44.	Operation and Maintenance Costs	$ 7,500.00	200
45.	Total Cost	$ 453,000.00	-
46.	Cost of Energy	$ 0.91/Kwh	2000

VECS SUMMARY SHEET

MANUFACTURER:	HOWDEN GROUP CANADA LTD.
ADDRESS:	1510 BIRCHMOUNT ROAD, SCARBOROUGH, ONTARIO M1P 2G6
CONTACT PERSON:	I. HOWITT
TELEPHONE NO.	(416) 752 7310
TELEX:	06 963 609
TURBINE MODEL:	HWP 330
TYPE (VAWT, HAWT):	HAWT
TURBINE DIMENSIONS:	26 m.OR 31 m. ROTOR DIAMETER,
SWEPT (CAPTURE) AREA:	531 m.^{2}/755 m.^{2} 26 m. HEIGHT
NUMBER OF BLADES:	3
CUT-IN WIND SPEED:	5.75 m/s(26 m.) 5 m/s (31 m.)
RATED WIND SPEED:	14.5 m/s (26 m.) 12.25 m/s (31 m.)
RATED POWER:	330 Kw.
CUT-OUT WIND SPEED:	28 m/s
ROTOR RPM:	38 rpm.
YAWING METHOD:	HYDRAULIC MECHANICAL LOCK
ALIGNMENT (UPWIND, DOWNWIND):	UPWIND

WEIGHTING TOTAL: 10925

DATE: 1984 12 18
COMPLETED BY: PH

WIND ENERGY CONVERSION SYSTEM
EVALUATION FORM

ITEM	CRITERIA	DATA	WEIGHTING
	GENERAL		
1.	Annual Energy Output/Annual Average Wind Speed	1,040,000 Kw Hr. at 8 m/s	-
2.	Design Minimum Life	25 years	100
3.	Maximum Power	333 Kw. at 12.25 m/s	-
4.	Power Curve	attached based on IEA	100
5.	Turbine Tower Features	tubular, free-standing, steel galvanised, internal ladder and access	100
6.	Standard Height at Hub or Equator	26 m.	-
7.	Height Option	none	0
8.	Blade Material	wood epoxy composite	50
9.	Electrical System	synchronous or induction, 460 V. 3 phase 60 Hz 1800 rpm	-
10.	Ambient Operating Temperature	- 30°C. to 40°C.	100
11.	Starting Arrangement	self-starting	-
	WIND SPEED		
12.	Maximum Design Wind Speed	58 m/s	200
13.	Maximum Tested Wind Speed	55 m/s	150
14.	Failures due to High Wind	none	100
15.	Overspeed Control	tip sections, automatically deploy plus disc brake both automatic reset	100
	SAFETY & PROTECTION		
16.	Maximum Ice Load	we have experienced no significant ice loading todate	0
17.	Ice Detection	ice detection system non-standard	-
18.	Ice Detection Experience	no failures or icing problems	0

EVALUATION FORM

ITEM	CRITERIA	DATA	WEIGHTING
	SAFETY & PROTECTION (Cont'd)		
19.	Noise Level	53 dBA at 100 m. in 6-7 m/s wind	100
20.	Vibration Protection	yes - auto reset	-
21.	Proximity to Dwelling	500 m.	-
22.	Manual Operated Brake	yes - manual control in tower base	500
23.	Lightning Protection	yes	500
24.	Skills of O & M Personnel	yes	100
25.	Service and Maintenance Equipment	none - built in hoist	800
26.	Machine Evaluation	yes - North of Scotland Hydro Electric Board	2000
27.	Additional Safety/Security Features	full safety/security see attached specification	-
28.	Availability Guarantee	yes - 90% of annual energy production	500
29.	Power Production Guarantee	yes - 90% of rated power	500
30.	Maximum Design Wind Speed Guarantee	yes - contingent on satisfactory wind data	500
31.	General Guarantee	all parts and labour for one year five year option at extra cost	1000
	PHYSICAL CONSTRAINTS		
32.	Total System Weight	60,000 lb.	-
33.	Weight of Heaviest Component	6,000 lb. gearbox	-
34.	Length of Longest Component	15 m. blade	-
35.	Erection and Installation Equipment	8 ton capacity mobile crane 12 ton capacity winch 10 m. high 'A' frame	200
36.	Erection and Installation Assistance	installation supervision provided at additional cost	25

ITEM	CRITERIA	DATA	WEIGHTING
	EXPERIENCE		
37.	Number of Machines in Operation	one	1
38.	Number of Year Model in Production	one	50
39.	Delivery Time	5 months	100
40.	Wind/Diesel Experience	our machine on Orkney feeds a weak island system of diesels occasionally when mainland cable connection is out	0
41.	Availability	87.9	-
	COSTS		
42.	Turbine Cost	$ 576,000.00	-
43.	Erection and Installation Costs	$ 84,000.00	-
44.	Operation and Maintenance Costs	$ 12,000.00	200
45.	Total Cost	$ 660,000.00	-
46.	Cost of Energy	$ 0.63/Kwh	1000

WECS SUMMARY SHEET

MANUFACTURER:	Polymarin B.V.
ADDRESS:	Nijverheidsweg 7,1671 GC MEDEMBLIK,Holland
CONTACT PERSON:	J.Olthoff
TELEPHONE NO.:	02274 - 3044
TELEX:	57430

TURBINE MODEL:	Pionier I
TYPE (VAWT, HAWT):	V.A.W.T.
TURBINE DIMENSIONS:	height 22,5 mtr. width 15 mtr.
SWEPT (CAPTURE) AREA:	150 m2
NUMBER OF BLADES:	2
CUT-IN WIND SPEED:	5 m./sec.
RATED WIND SPEED:	15 m./sec.
RATED POWER:	100 kW
CUT-OUT WIND SPEED:	20 m./sec
ROTOR RPM:	60 rpm
YAWING METHOD:	none
ALIGNMENT (UPWIND, DOWNWIND):	none

WEIGHTING TOTAL: 8819
DATE: 1984 12 18
COMPLETED BY: PW

WIND ENERGY CONVERSION SYSTEM
EVALUATION FORM

ITEM	CRITERIA	DATA	WEIGHTING
	GENERAL		
1.	Annual Energy Output/Annual Average Wind Speed	97.4 Mwh/year	-
2.	Design Minimum Life	20 years	75
3.	Maximum Power	100 kW. 15 m/sec.	-
4.	Power Curve	based on field tests from E.C.N. 1983	100
5.	Turbine Tower Features	tubular,steel,self-supporting,inside ladder, hot galvanized	100
6.	Standard Height at Hub or Equator	15 M at equator	-
7.	Height Option	standard only	0
8.	Blade Material	fiber glass/polyester	50
9.	Electricle System	DC-generator, 102 Kw, 400 V,1440 Rpm	-
10.	Ambient Operating Temperature	DC-AC Transducer - 1phase 3 x 380 V/50 Hz -30° to 50°	100
11.	Starting Arrangement	windspeed meter activates automatic starting device	0
	WIND SPEED		
12.	Maximum Design Wind Speed	56 m/sec.	200
13.	Maximum Tested Wind Speed	50 m/sec.	150
14.	Failures due to High Wind	0	335
15.	Overspeed Control	mechanical brake, normal - breaking with the generator - auto reset;excessive - belt brake non auto reset	300
	SAFETY & PROTECTION		
16.	Maximum Ice Load	40 mm. at 65 km/h	100
17.	Ice Detection	no ice detection standard	-
18.	Ice Detection Experience	some experience/no failure	1

EVALUATION FORM

ITEM	CRITERIA	DATA	WEIGHTING
	SAFETY & PROTECTION (Cont'd)		
19.	Noise Level	still under testing	0
20.	Vibration Protection	yes, avio typet	-
21.	Proximity to Dwelling	150 m.	-
22.	Manual Operated Brake	yes, hydraulic brake at control panel	500
23.	Lightning Protection	yes	500
24.	Skills of O & M Personnel	yes	300
25.	Service and Maintenance Equipment	non	800
26.	Machine Evaluation	yes, E.C.N. 1982 r. now	2000
27.	Additional Safety/Security Features	overtemperature indications, undervoltage protection, overload protection, grid break down protection generator break down protection.	-
28.	Availability Guarantee	no	0
29.	Power Production Guarantee	no	0
30.	Maximum Design Wind Speed Guarantee	no	0
31.	General Guarantee	all products have standard one-year parts and labour warranty	200
	PHYSICAL CONSTRAINTS		
32.	Total System Weight	11.200 kg./22.5 mt.	-
33.	Weight of Heaviest Component	5560 kg./towersection	-
34.	Length of Longest Component	15 x 1 m. diam. : towersection, 5560 kg.	-
35.	Erection and Installation Equipment	1-15 ton crane with 20 m. boom	600
36.	Erection and Installation Assistance	yes, costs depending on location	25

ITEM	CRITERIA	DATA	WEIGHTING
	EXPERIENCE		
37.	Number of Machines in Operation	1	1
38.	Number of Year Model in Production	not applicable	0
39.	Delivery Time	12 months	0
40.	Wind/Diesel Experience	zero	0
41.	Availability	95% downtime primarily due to testing	-
	COSTS		
42.	Turbine Cost	Dfl. 300.000,--	-
43.	Erection and Installation Costs	normaly included;except cables and grid connection.	-
44.	Operation and Maintenance Costs	1,5% of total cost	200
45.	Total Cost	Dfl. 300.000,--	-
46.	Cost of Energy	Dfl. 2,91/kWh c $ 0.99/kW/h	3000

WECS SUMMARY SHEET

MANUFACTURER: H.M.Z. Windmaster
ADDRESS: Reilestraat 3, B-3800 Sint Truiden, Belgium
CONTACT PERSON: S. HIJSSEN
TELEPHONE NO.: 011 - 68.06.66
TELEX: 39231

TURBINE MODEL: 100KW/22
TYPE (VAWT, HAWT): H.A.W.T.
TURBINE DIMENSIONS: HUB H 23 m - Rotor ø 22 m
SWEPT (CAPTURE) AREA: 373 m 2 - 4018 ft 2
NUMBER OF BLADES: 3
CUT-IN WIND SPEED: 4,5 - 5 m/sec. - 10-11 MPH
RATED WIND SPEED: 10,8 m/sec. - 24,2 MPH
RATED POWER: 100 KW by asynchronous generator
CUT-OUT WIND SPEED: 22 m/sec - 50 MPH.
ROTOR RPM: 48 RPM
YAWING METHOD: Active yaw - wind direction sensor
ALIGNMENT (UPWIND, DOWNWIND): upwind

WEIGHTING TOTAL: 10486
DATE: 1984 12 18
COMPLETED BY: PW

WIND ENERGY CONVERSION SYSTEM
EVALUATION FORM

ITEM	CRITERIA	DATA	WEIGHTI
	GENERAL		
1.	Annual Energy Output/Annual Average Wind Speed	See annex 332 MWh	-
2.	Design Minimum Life	200.000 Hours 22 Years	75
3.	Maximum Power	See annex 125 kW @ 10.5 m/s	-
4.	Power Curve	Par 6 min. - average 1 min. during 10 sec.	300
5.	Turbine Tower Features	Tubular tapered welded steel - Hot-dip galv. - 2 parts: 8 bolts ø 17.200 lbs	75
6.	Standard Height at Hub or Equator	Net hub height 22,8 m	-
7.	Height Option	30 m - 98,4 ft	-
8.	Blade Material	Polyester reinforced fiberglass topcoat-gelcoat	50
9.	Electricle System	See annex 100 kW, 480 VAC, 3 PH	-
10.	Ambient Operating Temperature	-30°C to + 50°C (-22°F to °F)	100
11.	Starting Arrangement	Maincontactor - 3 PHSE - 300 A - Clockner - Moller - 3 pcs. phase	-
	WIND SPEED		
12.	Maximum Design Wind Speed	Survival windspeed 67m/sec ... MPH	200
13.	Maximum Tested Wind Speed	112,5 MPH / 50 m/s	150
14.	Failures due to High Wind	We haven't got any malfunctions till now	316
15.	Overspeed Control	Autom. bladepitch regulation blade feathering, computer contr.	300
	SAFETY & PROTECTION		
16.	Maximum Ice Load	See annex	0
17.	Ice Detection	Optional Anti vibration equipment	-
18.	Ice Detection Experience	none	0
		note : gelcoat on polyester blades have low ice addition properly	

EVALUATION FORM

ITEM	CRITERIA	DATA	WEIGHTING
	SAFETY & PROTECTION (Cont'd)		
19.	Noise Level	52 db at 50m - 164 ft. 30 db at 150m - 492 ft.	100
20.	Vibration Protection	Vibration detection switch Auto reset optional	-
21.	Proximity to Dwelling	10 x rotordiam in line	-
22.	Manual Operated Brake	Yes, override switch located at tower base. 1-Manuel brake. 2-disc pitching	500
23.	Lightning Protection	Yes, by means of varistors	500
24.	Skills of O & M Personnel	Electric-mecanic-hydral. Engineer	0
25.	Service and Maintenance Equipment	Min. 60 ton crane - 45 m ft boom. except spare part kit	0
26.	Machine Evaluation	Yes, bij Belgian Min. of Public Works 26.04.1982	2000
27.	Additional Safety/Security Features	All functions are computer controlled See copy of synoptic panel	-
28.	Availability Guarantee	See spec. insurance	500
29.	Power Production Guarantee	See spec. insurance	500
30.	Maximum Design Wind Speed Guarantee	System has been constructed to withstand 67 m/s. See page item 13	500
31.	General Guarantee	All parts have standard one year warranty - See Windmaster warranty 5 years limited to insurance package	1000
	PHYSICAL CONSTRAINTS		-
32.	Total System Weight	See annex 15.5 tons/37.000 lbs	-
33.	Weight of Heaviest Component	See annex 7.500 kg/16.714 lbs	-
34.	Length of Longest Component	See optional information item 34	-
35.	Erection and Installation Equipment	1 - 60 tons crane cranehook at 45 m height	600
36.	Erection and Installation Assistance	1 M.M.Z. Engineer - one week at US $ 350 per day + travel and hotel expenses	25

ITEM	CRITERIA	DATA	WEIGHT.
	EXPERIENCE		
37.	Number of Machines in Operation	See added reference list	0
38.	Number of Year Model in Production	Four years	200
39.	Delivery Time	4 months - F.O.B. Antwerp	100
40.	Wind/Diesel Experience	See added page	0
41.	Availability	02,5 % - downtime due to preventive main proced. to keep windfarm in good shape	-
	COSTS	Californian windpark at 98 % from July 1984	-
42.	Turbine Cost	US $ - F.O.B. Antwerp	-
43.	Erection and Installation Costs	See added page, item 43	-
44.	Operation and Maintenance Costs	See added page, item 44	200
45.	Total Cost	Approx. : 190.000,- C $	-
46.	Cost of Energy	See option info. C$0.57/kWh	2000

WECS SUMMARY SHEET

MANUFACTURER: H.M.Z. WindMaster
ADDRESS: Rellestraat 3, B-3800 Sint Truiden, Belgium.
CONTACT PERSON: S. NIJSSEN
TELEPHONE NO.: 011 - 68.06.66
TELEX: 39231

TURBINE MODEL: 150KW/22
TYPE (VAWT, HAWT): H.A.W.T.
TURBINE DIMENSIONS: HUB H. 23m-ROTOR ø 22m.
SWEPT (CAPTURE) AREA: 373m2 - 4018 Ft^2.
NUMBER OF BLADES: 3
CUT-IN WIND SPEED: 4,5 - 5m/sec.
RATED WIND SPEED: 28 MPH
RATED POWER: 150 KW by asynchronous generator
CUT-OUT WIND SPEED: 56 MPH
ROTOR RPM: 52 RPM
YAWING METHOD: Active Yaw - Wind direction sensor
ALIGNMENT (UPWIND, DOWNWIND): Upwind

WEIGHTING TOTAL: 10560
DATE: 1984 12 18
COMPLETED BY: PM

WIND ENERGY CONVERSION SYSTEM
EVALUATION FORM

ITEM	CRITERIA	DATA	WEIGHTING
	GENERAL		
1.	Annual Energy Output/Annual Average Wind Speed	352 MWH - See added computer calculation - at 6.3 m/sec.	-
2.	Design Minimum Life	200.000 Hours	75
3.	Maximum Power	176KW 13 m/sec. 29,25 MPH	-
4.	Power Curve	Par 6 min. - average 1 min. during 10 sec.	300
5.	Turbine Tower Features	Tubular tapered welded steel - Hot-dip galv. - 2 parts: 84tons - 17.200 lbs.	75
6.	Standard Height at Hub or Equator	Net hub height 22,8 m	-
7.	Height Option	30 m - 98,4 ft	0
8.	Blade Material	Polyester reinforced fiberglass topcoat-gelcoat	50
9.	Electricle System	Induction generator 150KW,480VAC 3 PHSE, 60Hz - 1800 RPM	-
10.	Ambient Operating Temperature	-30°C to + 50°C (-22°F to °F)	100
11.	Starting Arrangement	Maincontactor - 3 PHSE - 300 A - Clockwor...Muller...1.500.000CT	-
	WIND SPEED		
12.	Maximum Design Wind Speed	Survival windspeed 67m/sec...MPH	200
13.	Maximum Tested Wind Speed	112,5 MPH	200
14.	Failures due to High Wind	We haven't got any malfunctions till now	336
15.	Overspeed Control	Autom. bladepitch regulation blade feathering, computer contr.	300
	SAFETY & PROTECTION		0
16.	Maximum Ice Load	See annex	
17.	Ice Detection	Optional Anti vibration equipment	-
18.	Ice Detection Experience	none note . gelcoat on polyester blades have low ice addition property	0

EVALUATION FORM

ITEM	CRITERIA	DATA	WEIGHTING
	SAFETY & PROTECTION (Cont'd)		
19.	Noise Level	52 db at 50m - 164 ft. 30 db at 150m - 492 ft.	300
20.	Vibration Protection	Vibration detection switch auto reset optional	-
21.	Proximity to Dwelling	10 x rotordiam in line	-
22.	Manual Operated Brake	Yes, override switch located at tower base. 1-manuel brake, 2-bladepitching	500
23.	Lightning Protection	Yes, by means of varistors	500
24.	Skills of O & M Personnel	Electric-mecanic-hydral. Engineer	0
25.	Service and Maintenance Equipment	Min. 60 ton crane - 45 m ft boom. except spare part kit	0
26.	Machine Evaluation	Yes, bij Belgian Min. of Public Works 26.04.1982	2000
27.	Additional Safety/Security Features	All functions are computer controlled See copy of synoptic panel	
28.	Availability Guarantee	See spec. insurance	500
29.	Power Production Guarantee	See spec. insurance	500
30.	Maximum Design Wind Speed Guarantee	System has been constructed to with- stand 67 m/s. See page item 13	500
31.	General Guarantee	All parts have standard one year warranty - See WindMaster warranty 5 years limited to insurance package	1000
	PHYSICAL CONSTRAINTS		
32.	Total System Weight	18,5 tons - 37.000 lbs.	-
33.	Weight of Heaviest Component	+ 8.000 kg (18.180Lbs) nacelle	-
34.	Length of Longest Component	See optional information item 34	-
35.	Erection and Installation Equipment	1 - 60 tons crane cranehook at 45 m height	600
36.	Erection and Installation Assistance	1 M.M.Z. Engineer - one week at US $ 350 per day + travel and hotel expenses	25

ITEM	CRITERIA	DATA	WEIGHTING
	EXPERIENCE		
37.	Number of Machines in Operation	See added reference list	0
38.	Number of Year Model in Production	Four years	200
39.	Delivery Time	4 months - F.O.B. Antwerp	100
40.	Wind/Diesel Experience	See added page	0
41.	Availability	92,5 % - downtime due to preventive main proced. to keep windfarm in good shape Californian windpark at 98 % from July 1984	-
	COSTS		-
42.	Turbine Cost	US $ - F.O.B. Antwerp	
43.	Erection and Installation Costs	See added page, item 43	-
44.	Operation and Maintenance Costs	See added page, item 44	200
45.	Total Cost	Approx. : 190.000,- C $	-
46.	Cost of Energy	See option info. C$0,54/kWh	2000

WECS SUMMARY SHEET

MANUFACTURER: N.M.Z. WindMaster
ADDRESS: Rellestraat 3, B-3600 Sint Truiden, Belgium
CONTACT PERSON: S. NIJSSEN
TELEPHONE NO.: 011 - 68.06.66
TELEX: 39231

TURBINE MODEL: 200 KW/22
TYPE (VAWT, HAWT): H.A.W.T.
TURBINE DIMENSIONS: HUUH. 23 m. - Rotor ø 22 m
SWEPT (CAPTURE) AREA: 373 m2 - 4018 ft. 2
NUMBER OF BLADES: 3
CUT-IN WIND SPEED: 4,5 - 5 m/sec. - 10-11MPH
RATED WIND SPEED: 14,5 m/sec - 32,9 MPH
RATED POWER: 200KW by asynchronous generator
CUT-OUT WIND SPEED: 25 m/sec. - 56 MPH
ROTOR RPM: 54 RPM
YAWING METHOD: active yaw - wind direction sensor
ALIGNMENT (UPWIND, DOWNWIND): upwind

WEIGHTING TOTAL: 10436
DATE: 1984 12 18
COMPLETED BY: PW

WIND ENERGY CONVERSION SYSTEM
EVALUATION FORM

ITEM	CRITERIA	DATA	WEIGHTING
	GENERAL		
1.	Annual Energy Output/Annual Average Wind Speed	See annex. 394 MWh	-
2.	Design Minimum Life	200.000 Hours	75
3.	Maximum Power	See annex 215 kW	-
4.	Power Curve	Par 6 min. - average 1 min. during 10 sec.	300
5.	Turbine Tower Features	Tubular tapered welded steel - Hot-dip galv. - 2 parts: Bolted - 17.200 lbs.	100
6.	Standard Height at Hub or Equator	Net hub height 22,8 m	-
7.	Height Option	30 m - 98,4 ft	0
8.	Blade Material	Polyester reinforced fiberglass topcoat-gelcoat 215kW, 4de Vac, 5 Ph	50
9.	Electricle System	See annex	-
10.	Ambient Operating Temperature	-30°C to + 50°C (-22°F to °F)	100
11.	Starting Arrangement	Maincontactor - 3 PHSE - 300 A - Cipeskopp. - Haller. - See annex	-
	WIND SPEED		143
12.	Maximum Design Wind Speed	Survival windspeed 67m/sec. ... MPH	200
13.	Maximum Tested Wind Speed	112,5 MPH / 50 m/s	150
14.	Failures due to High Wind	We haven't got any malfunctions till now	116
15.	Overspeed Control	Autom. bladepitch regulation blade feathering, computer contr.	300
	SAFETY & PROTECTION		
16.	Maximum Ice Load	See annex	0
17.	Ice Detection	Optional Anti vibration equipment	-
18.	Ice Detection Experience	none note : gelcoat on polyester blades have low ice addition property	0

EVALUATION FORM

ITEM	CRITERIA	DATA	WEIGHTING
	SAFETY & PROTECTION (Cont'd)		
19.	Noise Level	52 db at 50m - 164 ft. 30 db at 150m - 492 ft.	100
20.	Vibration Protection	Vibration detection switch auto reset optional	-
21.	Proximity to Dwelling	10 x rotordiam in line	-
22.	Manual Operated Brake	Yes, override switch located at tower base. 1-Manuel brake. 2-bladepitching	500
23.	Lightning Protection	Yes, by means of varistors	500
24.	Skills of O & M Personnel	Electric-mecanic-hydral. Engineer	0
25.	Service and Maintenance Equipment	Min. 60 ton crane - 45 m ft boom. except spare part kit	0
26.	Machine Evaluation	Yes, bij Belgian Min. of Public Works 26.04.1982	2000
27.	Additional Safety/Security Features	All functions are computer controlled See copy of synoptic panel	-
28.	Availability Guarantee	See spec. insurance	500
29.	Power Production Guarantee	See spec. insurance	500
30.	Maximum Design Wind Speed Guarantee	System has been constructed to with- stand 67 m/s. See page item 13	500
31.	General Guarantee	All parts have standard one year warranty - See WindMaster warranty 5 years limited to insurance package	1000
	PHYSICAL CONSTRAINTS		
32.	Total System Weight	18,5 tons - 37.000 Lbs.	-
33.	Weight of Heaviest Component	See annex	-
34.	Length of Longest Component	See optional information itemm34	-
35.	Erection and Installation Equipment	1 - 60 tons crane cranehook at 45 m height	600
36.	Erection and Installation Assistance	1 W.M.Z. Engineer - one week at US $ 350 per day + travel and hotel expenses	25

ITEM	CRITERIA	DATA	WEIGHTI
	EXPERIENCE		
37.	Number of Machines in Operation	See added reference list	0
38.	Number of Year Model in Production	Four years	200
39.	Delivery Time	4 months - F.O.B. Antwerp	100
40.	Wind/Diesel Experience	See added page	0
41.	Availability	92,5 % - downtime due to preventive main proced. to keep windfarm in good shape	-
	COSTS	Californian windpark at 98 % from July 1984	
42.	Turbine Cost	US $ - F.O.B. Antwerp	-
43.	Erection and Installation Costs	See added page, item 43	-
44.	Operation and Maintenance Costs	See added page, item 44	200
45.	Total Cost	Approx. : 190.000,- C $	-
46.	Cost of Energy	See option info. c $ 0.53/kWh	2000

WECS SUMMARY SHEET

MANUFACTURER: VESTAS ENERGY A/S
ADDRESS: DK-6940 LEM, DENMARK
CONTACT PERSON: Mr. Nils Andersen, Export Manager
TELEPHONE NO.: 45 - 7 - 34 11 88
TELEX: 60 733

TURBINE MODEL: VESTAS V-15
TYPE (VAWT, HAWT): 65/13 kW
TURBINE DIMENSIONS: height 24.4/11.9 m
SWEPT (CAPTURE) AREA: 184 m² (1972 ft²)
NUMBER OF BLADES: 3
CUT-IN WIND SPEED: 4 m/sec (8.9 mph)
RATED WIND SPEED: 16 m/sec (35 mph)
RATED POWER: High wind 65 kW - Low wind 13 kW
CUT-OUT WIND SPEED: 26 m/sec (58 mph)
ROTOR RPM: High wind 52.7 rpm - Low wind 42.2 rpm
YAWING METHOD: Active, electric motor with double worm gear reduction
ALIGNMENT (UPWIND, DOWNWIND): Up wind

WEIGHTING TOTAL: 1043?
DATE: 1984 12 19
COMPLETED BY: DH

WIND ENERGY CONVERSION SYSTEM EVALUATION FORM

ITEM	CRITERIA	DATA	WEIGHTING
	GENERAL	130,000 kWh/yr based on Rayleigh distribution.	
1.	Annual Energy Output/Annual Average Wind Speed	Annual average wind speed 14 mph (6.3 m/s)	-
2.	Design Minimum Life	25 years	100
3.	Maximum Power	78 kW at 25 m/sec. (56 mph)	-
4.	Power Curve	Based on field test by Zond Systems Inc., California, USA	300
5.	Turbine Tower Features	Bolted angular iron elements Lattice, hot-galvanized steel external ladder	60
6.	Standard Height at Hub or Equator	24.4 m (80 ft).	-
7.	Height Option	31.9 m (104 ft)	50
8.	Blade Material	Fiber glass reinforced Polyester	50
9.	Electricle System	2 induction generators, main generator 65 kW, small generator 13 kW, 480 VAC.	-
10.	Ambient Operating Temperature	- 20° C to 40° C	50
	Starting Arrangement	Self start at 5-6 m/sec. wind Manual motor start	-
	WIND SPEED	50 m/sec. (110 mph)	150
12.	Maximum Design Wind Speed		
13.	Maximum Tested Wind Speed	44 m/sec. (97 mph)	50
14.	Failures due to High Wind	None	132
15.	Overspeed Control	Aerodynamic brakes, pivotable tips on blades Hydraulic dual-caliper, disc brake, automatically rese	300
	SAFETY & PROTECTION		
16.	Maximum Ice Load	Unknown	0
17.	Ice Detection	Shock sensor	-
18.	Ice Detection Experience	4 Danish ice Winters with temperature down to -10° C.	0

EVALUATION FORM

ITEM	CRITERIA	DATA	WEIGHTING
	SAFETY & PROTECTION (Cont'd)	42 DB(A) at 70 m	
19.	Noise Level		300
20.	Vibration Protection	Yes, manual reset	-
21.	Proximity to Dwelling	100 m (328 ft)	-
22.	Manual Operated Brake	Yes, by turning the key switch at control panel	500
23.	Lightning Protection	Protection of electrical components against voltage transients caused inductively by lightning etc. See attached description.	500
24.	Skills of O & M Personnel	4 weeks training can be offered for total O & M, 2 days instruction for operating and normal service are included in the price.	300
25.	Service and Maintenance Equipment	1 50 ton mobile crane, lifting capacity 10 ton, 25 m under hook, 10 m jib	0
26.	Machine Evaluation	Machine evaluation carried out every year by RISØ National Lab.	2000
27.	Additional Safety/Security Features	Safety lines, platforms	-
28.	Availability Guarantee	Yes, 90% in the wind area 4 m/sec. to 26 m/sec	500
29.	Power Production Guarantee	Yes, according to the attached power curve	500
30.	Maximum Design Wind Speed Guarantee	50 m/sec. (110 mph)	500
31.	General Guarantee	All products have standard two-year parts warranty excl. labour.	400
	PHYSICAL CONSTRAINTS	8300 kgs (18282 lbs) 23.4 m (76.77 ft)	
32.	Total System Weight		-
33.	Weight of Heaviest Component	3700 kgs (8150 lbs) tower	-
34.	Length of Longest Component	8 m (26 ft)	-
35.	Erection and Installation Equipment	150 tonnes mobile crane lifting capacity 10 25 m under hook, 10 m jib truck with crane - 20 meter tonnes	400
36.	Erection and Installation Assistance	Yes, additional cost in D.kr. 2500.00/day plus air ticket Duration of erection approx. 1 week	25

ITEM	CRITERIA	DATA	WEIGHTI
	EXPERIENCE	Present 290 units of the 65 kW (By the end of the year 700 units) 250 units of the 55 kW	
37.	Number of Machines in Operation		870
38.	Number of Year Model in Production	6 65 kW 2 years - 15 55 kW more than 3 years 157 65 kW 1 year - 50 55 kW more than 2 years	100
39.	Delivery Time	2-3 months	100
40.	Wind/Diesel Experience	Some	0
41.	Availability	95% to 98%	-
	COSTS	D.kr. 420,000.00 FOB Danish Port	
42.	Turbine Cost	Tower size 23.4 m height	
43.	Erection and Installation Costs	Approx. D.kr. 50,000.00	-
44.	Operation and Maintenance Costs	Approx. D.kr. 3,200.00/year	200
45.	Total Cost	D.kr. 470,000.00	-
46.	Cost of Energy	D.kr. 3.61/kWh ~ C$ 0.45/kWh	2000

WECS SUMMARY SHEET

MANUFACTURER: EXTRAWATT INC.

ADDRESS: 220-rue principale- c.p. 15, St-Jean de la Lande
C.P. Hamel, Beauce-Sud, P.Q. G0M 1E0

CONTACT PERSON: MARTIN CLOUTIER

TELEPHONE NO.: (418) 228-5999
228-1984

TELEX:

TURBINE MODEL: EX - 10

TYPE (VAWT, HAWT): HAWT

TURBINE DIMENSIONS: 32 feet ϕ

SWEPT (CAPTURE) AREA: 804 pi.^{2}

NUMBER OF BLADES: 3

CUT-IN WIND SPEED: 7 m.p.h.

RATED WIND SPEED: 30 m.p.h.

RATED POWER: 10 KW

CUT-OUT WIND SPEED: none

ROTOR RPM: 100 r.p.m.

YAWING METHOD: Mechanical -

ALIGNMENT (UPWIND, DOWNWIND): Downwind

WEIGHTING TOTAL: 6895

DATE: 1984 12 10

COMPLETED BY: PW

WIND ENERGY CONVERSION SYSTEM
EVALUATION FORM

ITEM	CRITERIA	DATA	WEIGHTING
	GENERAL		
1.	Annual Energy Output/Annual Average Wind Speed	65000 KWH (14 mph annual aver. wind)	-
2.	Design Minimum Life	25 years	100
3.	Maximum Power	10 Kw @ 30 mph	-
4.	Power Curve	Field test at I.R.E.Q. (Qué)	100
5.	Turbine Tower Features	Steel Pole, guyed wires	65
6.	Standard Height at Hub or Equator	60 feet	-
7.	Height Option		0
8.	Blade Material	Reinforced fiberglass Partial Steel core	50
9.	Electricle System	Induction Generator 10 KW 240 VAC, 1ϕ, 60HZ, 1800 R.P.M.	-
10.	Ambient Operating Temperature	-20°F A 100°F	50
11.	Starting Arrangement	none	-
	WIND SPEED		
12.	Maximum Design Wind Speed	100 MPH	150
13.	Maximum Tested Wind Speed	60MPH	0
14.	Failures due to High Wind	Possibility blade in a veery hight wind	180
15.	Overspeed Control	Furling Blade Feathering Mechanical Brake manually Reset	100
	SAFETY & PROTECTION		
16.	Maximum Ice Load	1 inch	0
17.	Ice Detection	vibration/Brake manually reset	-
18.	Ice Detection Experience	4 years	-

EVALUATION FORM

ITEM	CRITERIA	DATA	WEIGHTING
	SAFETY & PROTECTION (Cont'd)		
19.	Noise Level		0
20.	Vibration Protection	Yes, Manual reset	-
21.	Proximity to Dwelling	500 feet	-
22.	Manual Operated Brake	Yes, Brake handle at tower base	500
23.	Lightning Protection	yes	500
24.	Skills of O & M Personnel	yes	300
25.	Service and Maintenance Equipment		800
26.	Machine Evaluation	yes, I.R.E.Q. (Qué.) 1981	2000
27.	Additional Safety/Security Features	Undervoltage protection	-
28.	Availability Guarantee	No	0
29.	Power Production Guarantee	No	0
30.	Maximum Design Wind Speed Guarantee	No	0
31.	General Guarantee	1 year full covered for any mechanical failure.	200
	PHYSICAL CONSTRAINTS		
32.	Total System Weight	4,500.	-
33.	Weight of Heaviest Component	Tower 2,000	-
34.	Length of Longest Component	30 feet	-
35.	Erection and Installation Equipment	towing truck	800
36.	Erection and Installation Assistance	No	100

ITEM	CRITERIA	DATA	WEIGHTING
	EXPERIENCE		
37.	Number of Machines in Operation		0
38.	Number of Year Model in Production	Within 1 year	0
39.	Delivery Time	4 A 6 months	100
40.	Wind/Diesel Experience	No	0
41.	Availability	90% 10% for maintenance	-
	COSTS		
42.	Turbine Cost	$ 25,000.00	-
43.	Erection and Installation Costs	$ 500.00	-
44.	Operation and Maintenance Costs	1.5% of total cost	200
45.	Total Cost	$ 26,000.00	-
46.	Cost of Energy	C$0.4/kWh	2000

APPENDIX D

REFERENCES

Reference No. 1

Atmospheric Environment Service
Building
Pleasantville
St. John's, Newfoundland

Telephone: (709) 772-4695

Contact: S. Porter

Reference No. 2

Atmospheric Environment Service
Downsview
Toronto, Ontario

Telephone: (709) 667-4953

Contact: Mr. M. Webb

Reference No. 3

Department of Forest Resources & Lands
Mapping Division
Howley Building
Higgins Line
St. John's, Newfoundland

Telephone: (709) 737-3305

Reference No. 4

Department of Mines & Energy
Eastern Canada Trust Building
Bonventure Avenue
St. John's, Newfoundland

Telephone: (709) 737-2776

Contact: Mr. J. Drover

Reference No. 5

Energy Mines & Resources
P.O. Box 65
215 Water Street
St. John's, NF A1C 6C9

Telephone: (709) 772-5464

Contact: Mr. P. Duffett

Reference No. 6

Department of Communications
Government of Canada
Sir Humphrey Gilbert Building
205 Duckworth Street
St. John's, NF

Telephone: (709) 772-4889

Contact: Mr. R. Wilcox

Reference No. 7

Memorial University Library

Telephone: (709) 737-7425

Contact: Ms. Sally Grenville

Reference No. 8

Newfoundland and Labrador Hydro
Philip Place
Elizabeth Avenue
St. John's, Newfoundland

Telephone: (709) 737-1210

Contact: Mr. S. Banfield

Reference No. 9

A. Town Clerk
Nain, Labrador
AOP 1LO

Telephone: (709) 922-2842

B. Mr. Philip Jeddore
Town Clerk
Davis Inlet, Labrador
AOP 1AO

C. Mr. Irvin Lane
Town Clerk
Postville, Labrador
AOP 1NO

Telephone: (709) 479-9830

D. Ms. Sheila Mitchell
Town Clerk
Makkovik, Labrador
AOK 1JO

Telephone: (709) 923-2221

E. Ms. Lorraine Allen
Town Clerk
Rigolet, Labrador
AOP 1PO

Telephone: (709) 947-3382

F. Mr. Harris Learning
Town Clerk
Paradise River, Labrador
AOK 3YO

Telephone: (709) 845-5243

Reference No. 9 (Cont'd.)

G. Ms. Shirley Mullins
Town Clerk
Cartwright, Labrador
AOK 1VO

Telephone: (709) 938-7259

H. Ms. Brenda Roberts
Town Clerk
Black Tickle, Labrador
AOK 1NO

Telephone: (709) 471-8844

I. Mr. Sandy Campbell
Town Clerk
Charlottetown, Labrador
AOK 5YO

Telephone: (709) 949-0027

J. Mr. Fred Sulley
Town Clerk
Williams Harbour, Labrador
AOK 5VO

Telephone: (709) 930-9100

K. Ms. Margaret Burden
Town Clerk
Port Hope Simpson, Labrador
AOK 4EO

Telephone: (709) 960-0222

L. Mr. Wilfred Rumbolt
Town Clerk
Saint Lewis, Labrador
AOK 3WO

Telephone: (709) 939-2239

Reference No. 9 (Cont'd.)

M. Mr. Clifford Campbell
Town Clerk
Mary's Harbour, Labrador
AOK 3PO

Telephone: (709) 921-6281

N. Mr. Reg O'Brien
Town Clerk
L'Anes Au Loup, Labrador
AOK 3LO

Telephone: (709) 927-5573